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Chem 3552.84 Bd. July, 1885.



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# A DICTIONARY

OF THE ACTION OF



## HEAT UPON CERTAIN METALLIC SALTS,

INCLUDING AN INDEX TO THE PRINCIPAL LITERATURE  
UPON THE SUBJECT,

COMPILED AND ARRANGED BY

J. W. BAIRD, M.A., PH.C.

CONTRIBUTED BY

PROF. A. B. PRESCOTT.

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Reprinted from the JOURNAL OF THE AMERICAN CHEMICAL SOCIETY.

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NEW YORK:  
BERMINGHAM & CO.,  
28 UNION SQUARE.

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1884.

1885 June 15  
Gift of  
The Science Co.

# A DICTIONARY OF THE ACTION OF HEAT UPON CERTAIN METALLIC SALTS,

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## INTRODUCTION.

It has been the aim of the author, in compiling the present work, to place in convenient form a fairly complete, and yet a concise, statement of the effect of heat upon metallic salts. No original experiments were made, nor anything introduced except that which could be accompanied by good authority. The works consulted comprise the leading journals of the present century and such works of reference as Gmelin-Kraut, Watts' Dictionary, etc., in all about 1200 volumes. Absolute completeness cannot be claimed, for such a claim could only be based upon exhaustive research through all the scientific works extant, a thing which in this case was utterly impossible; but comprising as it does a review of so many volumes, that represent the majority of experiments performed in the scientific world, it cannot be otherwise than practically complete.

Brevity has always been one of the objects held in view, and if in any case a more minute statement is desired, the authority itself can then be consulted, which in every instance accompanies the subject matter. Not only is reference to the original article given, which is always placed first, but also references to the briefs or abstracts of that article, care being taken to give accurately the volume and page.

There will be found given the melting and boiling points of the salts, the temperature at which disassociation takes place, the products of decomposition, both volatile and residual, and such other facts as fall within the scope of the subject, only just so far as these things are stated by the authorities consulted.

To all those who may have occasion to refer to this work, either for practical, chemical, or in short for any scientific purpose whatever, it is respectfully submitted.

J. W. BAIRD,

University, Ann Arbor, Mich., 1883.

## LIST OF WORKS CONSULTED.

*Annalen der Chemie und Pharmacie* and Supplements, from 1843 to 1881.

*Annalen der Physik und Chemie*, by J. C. Poggendorff, from 1824 to 1880.

*Annales de Chemie et de Physique*, from 1816 to 1880

*American Chemist*, from 1870 to 1876.

*American Journal of Pharmacy* from 1848 to 1880.

*Berichte der Deutschen Chemischen Gesellschaft zu Berlin*, from 1868 to 1880.

*Chemical News*, London, 1860 to 1882.

*Chemical Gazette*, London, 1842 to 1859.

*Comptes rendus*, Paris, 1857 to 1881.

*Edinburgh Philosophical Journal*, 1819 to 1824.

Gmelin-Kraut's *Handbuch der Chemie*, for all the salts except those of NH<sub>4</sub>, Sb, As, and Bi, for which was used

Gmelin's *Handbuch der Chemie*, translated by Watts.

*Jahresbericht über die Fortschritte der Chemie*, 1847 to 1879 except 1863 and 1864.

*Jahresbericht über die Fortschritte der Pharmacognosie, Pharmacie und Toxicologie*, 1866 to 1880.

*Journal für praktische Chemie*, 1834 to 1881.

*Journal of the Chemical Society of London*, 1849 to 1881.

*Miller's Inorganic Chemistry*.

*Philosophical Magazine and Journal of Science*, 1832 to 1882.

*Proceedings of the Royal Society of London*, 1856 to 1879.

Abstracts of the papers printed in the *Philosophical transactions of the Royal Society of London*, 1800 to 1855.

Roscoe and Schorlemmer's *Treatise on Chemistry*.

Watts' *Dictionary of Chemistry with supplements*.

*Zeitschrift für Analytische Chemie*, 1862 to 1881.

## EXPLANATORY NOTES.

The salts that are taken under consideration are the bromides, chlorides, iodides, nitrates, nitrites, phosphates, sulphates, sulphides, and sulphites, including only those of the common bases, viz., Al, NH<sub>4</sub>, Sb<sup>III</sup>, Sb<sup>V</sup>, As<sup>III</sup>, As<sup>V</sup>, Ba, Bi<sup>III</sup>, Cd, Ca, Cr<sup>III</sup>, Co<sup>II</sup>, Cu<sup>I</sup>, Cu<sup>II</sup>, Fe<sup>II</sup>, Fe<sup>III</sup>, Pb, Mg, Mn<sup>II</sup>, Mn<sup>III</sup>, Hg<sup>I</sup>, Hg<sup>II</sup>, Ni<sup>II</sup>, K, Na, Ag, Sn<sup>II</sup>, Sn<sup>IV</sup>, Sr, Zn, and that too only the normal salts, except in the case of the phosphates, where the mono-, di-, and tri-basic salts are given.

The temperatures are given on the Centigrade scale, excepting when the contrary is expressly stated.

The following is the list of the most important abbreviations :

Abstracts Phil. Trans. of Roy. Soc.—Abstracts of the Philosophical Transactions of the Royal Society.

Amer. Chem.—American Chemist.

Amer. J. Pharm.—American Journal of Pharmacy.

Amer. J. Sci.—American Journal of Science.

Annalen.—Annalen der Chemie und Pharmacie.

Ann. Chim. Phys.—Annales de Chimie et de Physique.

Ann. Chim.—Annales de chimie.

Arch. der Pharm.—Archiv der Pharmacie.

Arch. ne'-erland.—Archives ne'-erlandaises des Sciences.

Ber.—Berichte der deutschen chemischen Gesellschaft zu Berlin.

Berzelius Jahresb.—Jahresbericht über die Fortschritte der physischen Wissenschaften, oder der Chemie und Mineralogie. Jacob Berzelius.

Bull. Soc. chim.—Bulletin de la société chimique de Paris.

Br. Arch.—Archiv des Apothekervereins im nördlichen Deutschland.

Chem. Centr.—Chemisch-Pharmaceutisches, since 1857 Chemisches Centralblatt.

Chem. Gaz.—Chemical Gazette.

Chem. News.—Chemical News.

Chem. Soc. J.—Journal of the Chemical Society.

Compt. rend.—Comptes rendus hebdomadaires, des Séances de l'Académie des Sciences. Paris.

Crell. Ann.—Chemische Annalen by Dr. Crell.

Dingl. Pol. J.—Polytechnisches Journal. by E. M. Dingler.

Ed. Phil. J.—Edinburgh Philosophical Journal.

Gilb. Ann.—Annalen der Physik, afterwards der Physik und physikalischen Chemie, by L. W. Gilbert.

Gmelin-Kraut.—Gmelin's Handbuch by Kraut.

Gmelin. Watts' Transl.—Gmelin's Handbuch, translated by Watts.

Institut.—L'Institut, Paris.

Jahresb.—Jahresbericht für die Fortschritte der Chemie, Physik, Mineralogie und Geologie.

Jahresb. Ph. Tox.—Jahresbericht über Fortschritte der Pharmacognosie, Pharmacie und Toxicologie.

J. Chim. méd.—Journal de chimie médicale de pharmacie.



- J. Ph. Chim.—Journal de Pharmacie et de chimie.  
 J. pr. Chem.—Journal für praktische Chemie.  
 Miller.—Miller's Inorganic Chemistry.  
 Mag. der Pharm.—Magazin der Pharmacie.  
 Mem. and Proc. Chem. Soc.—Memoirs and Proceedings of the Chemical Society.  
 Mulhouse Soc. Bull.—Bulletin de la société industrielle de Mulhouse.  
 N. Gehl.—Journal für die Chemie und Physik by A. F. Gehlin.  
 N. Jahrb. Pharm.—Neues Jahrbuch für Pharmacie.  
 Pharm. Centr.—See Chem. Centr.  
 Pharm. J. Trans.—Pharmaceutical Journal and Transactions.  
 Phil. Mag. J.—Philosophical Magazine and Journal of Science.  
 Phil. Trans.—Philosophical Transactions.  
 Ph. Ch. Ber.—Philos. der Chemie. Berlin.  
 Pogg. Ann.—Annalen der Physik und Chemie. J. C. Poggendorff.  
 Proc. Amer. Acad.—Proceedings of the American Academy of Arts and Sciences.  
 Proc. Roy. Soc.—Proceedings of the Royal Society.  
 Rep. Ch. appli.—Repertoire de Chimie appliquée.  
 Rep. Ch. pure.—Repertoire de Chimie pure.  
 Ros. and Sch.—Roscoe and Schorlemmer's Chemistry.  
 Schw.—Journal für Chemie und Physik by Dr. S. C. Schweigger.  
 Tech. Jahr.—Jahresbericht über die Fortschritte der chemischen Technologie.  
 Trans. Roy. Soc. Ed.—Transactions of the Royal Society of Edinburgh.  
 Watts' Dict.—Watts' Dictionary of Chemistry.  
 Wiss. Acad. Ber.—Sitzungsberichte der k. k. Akademie der Wissenschaften.  
 Zeitschr. Anal. Chem.—Zeitschrift für analytische Chemie.  
 Zeitschr. Chem.—Zeitschrift für Chemie.  
 Zeitschr. Chem. Pharm.—Zeitschrift für Chemie und Pharmacie.

## THE BROMIDES.

*Aluminium Bromide.  $Al_2Br_6$ .*

Aluminium bromide melts at  $90^\circ$ , Rud. Weber (1) or at  $93^\circ$ , Deville and Troost (2), to a clear mobile liquid, which boils at  $265$ – $270^\circ$ , Rud. Weber (1), or at  $260^\circ$ , Deville and Troost (2). When heated in sealed tubes it sublimes, forming colorless glittering laminae, Rud. Weber (3); but when heated in the air it decomposes into hydro-bromic acid and aluminium oxide, Berthelot, (4) or into vapor of bromine and oxide of aluminium, Rud. Weber (5).

*Ammonium Bromide.  $NH_4Br$ .*

Ammonium bromide vaporizes in the heat without previous fusions (6).

*Antimonous Bromide.  $SbBr_3$ .*

Antimonous bromide melts at  $90^\circ$ , Kopp (1), R. W. Emerson MacIvor (2), at  $93^\circ$ , J. P. Cook (3), at  $94^\circ$ , H. Serullas (4), or at  $95^\circ$  (5) to a pale greenish-yellow colored liquid, which boils at or near  $283^\circ$ , R. W. Emerson MacIvor (2), at  $270^\circ$ , H. Serullas (6), at  $275.4^\circ$ , Kopp (7), or at  $280^\circ$ , J. P. Cook (3). When heated in a closed vessel it sublimes unchanged, H. Serullas (8).

*Arsenious Bromide.  $AsBr_3$ .*

Arsenious bromide melts at  $20$ – $25^\circ$  to a pale yellow liquid which boils at  $220^\circ$ , H. Serullas (9), and on cooling congeals in long prisms. When heated in closed vessels it sublimes unchanged, H. Serullas (10).

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(1) Pogg. Ann. 103. 259. J. pr. Chem. 74. 165. Chem. Gaz. 16. 269. Chem. Centr. 1858. 365. Jahresb. 10. 157. Gmelin-Kraut. 2. 1. 642. Watts Dict. 1. 156. Ros. and Sch. 2. 1. 447. (2) Jahresb. 12. 26. (3) Pogg. Ann. 103. 259. J. pr. Chem. 74. 165. Chem. Gaz. 16. 269. Ros. and Sch. 2. 1. 447. (4) Ann. Chim. Phys. 44. 394. (5) Pogg. Ann. 103. 266. Chem. Gaz. 16. 269. Chem. Centr. 1858. 365. Jahresb. 10. 157. Gmelin-Kraut. 2. 1. 642. Watts Dict. 1. 156. (6) Gmelin, Watts Translation, 2. 469.

(1) Annalen 95. 307. Pharm. Centr. 1855. 771. Jahresb. 8. 37. (2) Chem. News 29. 179. (3) Proceed. Amer. Acad. New Series 5. Ber. 11. 255. Jahresb. Ph. Tox. 1878. 259. Jahresb. 30. 384. (4) Pogg. Ann. 14. 111. Ann. Chim. Phys. 38. 322. (5) Ros. and Sch. 2. 2. 319. (6) Pogg. Ann. 14. 111. Ann. Chim. Phys. 38. 322. Gmelin, Watts Translation, 4. 364. Watts Dict., 1. 317. (7) Annalen 95. 307. Pharm. Centr. 1855. 771. Jahresb. 8. 37. Ros. and Sch. 2. 2. 319. (8) Pogg. Ann. 14. 111. Ann. Chim. Phys. 38. 322. Ros. and Sch. 2. 2. 319. (9) Pogg. Ann. 14. 111. Ann. Chim. Phys. 38. 320. Gmelin, Watts Transl. 4. 283. Watts Dict., 1. 371. Ros. and Sch. 1. 523. Miller 586. (10) Pogg. Ann. 14. 111. Ann. Chim. Phys. 38. 320. Gmelin, Watts Transl. 4. 283.

*Barium Bromide. BaBr.*

Anhydrous barium bromide melts at  $812^{\circ}$ , T. Carnelley (1). The salt crystallized with 2 mol. water melts when heated, Balard (2), and loses its water, C. Rammelsberg (3).

*Bismuth Bromide. BiBr.*

Bismuth bromide melts at  $198-200^{\circ}$ , R. W. E. MacIvor (4), at  $200^{\circ}$ , H. Serullas (5), or at  $210-215^{\circ}$ , M. P. Muir (6), to a hyacinth red liquid, which boils at a dark red heat, H. Serullas (5), R. W. E. MacIvor (4) or at  $454-498^{\circ}$  T. Carnelley and W. C. Williams (7). The salt can be sublimed unchanged, H. Serullas (8).

*Cadmium Bromide. CdBr, 4H<sub>2</sub>O.*

Crystallized cadmium bromide loses  $\frac{1}{2}$  its water at  $100^{\circ}$  and the other  $\frac{1}{2}$  at  $200^{\circ}$  without undergoing fusion, C. Rammelsberg (9); but when rapidly heated, it melts in its water of crystallization, becomes anhydrous and if the temperature be now raised to almost redness it entirely sublimes in the form of round pearly white scales, Berthemot (1). The anhydrous salt melts at  $571^{\circ}$ , T. Carnelley (2).

*Calcium Bromide. CaBr.*

Calcium bromide melts at  $676^{\circ}$ , T. Carnelley (3), at  $680^{\circ}$ , T. Carnelley (2) or at a strong red heat under separation of Bromine (4).

*Chromium Bromide. Cr<sub>2</sub>Br<sub>3</sub>.*

Chromium bromide decomposes when it is heated in the air, and leaves the green oxide of Chromium behind, Wöhler (5), Berthemot (6), Wöhler and Bauck (7).

*Cobaltous Bromide. CoBr, 6H<sub>2</sub>O.*

The crystallized cobaltous bromide fuses at  $100^{\circ}$ , loses water, and is found on cooling to be a mass of purplish-blue crystals covered with a blue opaque crust of  $\text{CoBr}, 2\text{H}_2\text{O}$ ; while at  $130^{\circ}$  the salt dries

(1) Chem. Soc. J. 83. 279. (2) Pogg. Ann. 8. 330. (3) Pogg. Ann. 55. 237. (4) Chem. Soc. J. 28. 133. Chem. News. 30. 190. (5) Pogg. Ann. 14. 111. Ann. Chim. Phys. 88. 818. Watts Dict. 1. 591. (6) Chem. Soc. J. 29. 144. Chem. News. 32. 277. Ros. and Sch. 2. 2. 337. (7) Chem. Soc. J. 33. 281. (8) Pogg. Ann. 14. 111. Ann. Chim. Phys. 88. 818. (9) Pogg. Ann. 55. 241. Gmelin-Kraut 3. 71. Watts Dict. 1. 703.

(1) Ann. Chim. Phys. 44. 388. Gmelin-Kraut 3. 71 (2) Chem. Soc. J. 33. 273. (3) Chem. Soc. J. 29. 439. Zeitschr. Anal. Chem. 17. 469. (4) Gmelin-Kraut 2. 1. 393. (5) Annalen 111. 383. Phil. Mag. J. (4) 18. 456. Gmelin-Kraut 2. 2. 313. (6) Ann. Chim. Phys. 44. 383. Gmelin-Kraut 2. 2. 313. (7) J. Ph. Chim. 1859. Chem. News. 1. 82.

to an opaque amorphous vivid green mass, consisting of the anhydrous salt, Walter Noel Hartley (1). When heated it leaves a bluish-green residue of the anhydrous salt, C. Rammelsberg (2), which melts at a strong red heat under some decomposition, Berthemot (3).

*Cupric Bromide.  $\text{CuBr}_2$ .*

Cupric bromide loses  $\frac{1}{2}$  its bromine even below a red heat and is thereby changed into cuprous bromide, Berthemot (4), C. Rammelsberg (5), (6).

*Cuprous Bromide.  $\text{Cu}_2\text{Br}_2$ .*

Cuprous bromide melts at a red heat, does not volatilize when heated in closed vessels, and only with difficulty in the air, Löwig (7). It will withstand a strong heat in a closed tube without decomposition, while in a crucible in contact with the air, it volatilizes in vapors which color the flame green and leaves a residue of cupric oxide behind, Berthemot (8). The salt decomposes by ignition in the air\* (1).

*Ferric Bromide.  $\text{Fe}_2\text{Br}_6$ .*

Ferric bromide, when heated in absence of air, fuses and part may be sublimed without decomposition, another portion however being decomposed into ferrous bromide and free bromine (2).

*Ferrous Bromide.  $\text{FeBr}_2$ .*

When ferrous bromide is heated to redness in contact with air, ferric bromide sublimes and ferric oxide is left as a residue, Löwig, (3). If the salt be reduced to a powder, put in a tube and heated to redness, it volatilizes; and when the temperature is raised still higher a little decomposes with the formation of vapors of bromine, Berthemot (4).

*Lead Bromide.  $\text{PbBr}_2$ .*

Lead Bromide melts at  $499^\circ$ , T. Carnelley (5) or at a strong heat to a red liquid, Balard (6), which, when the air is excluded, solidi-

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\* (1) Chem. Soc. J. 27. 501. Chem. News. 29. 161. Jahresb. 74. 273. Ross and Sch. 2. 2. 130. (2) Pogg. Ann. 55. 244. Gmelin-Kraut 3. 455. Ros. and Sch. 2. 2. 130. (3) Ann. Chim. Phys. 44. 391. Gmelin-Kraut 3. 455. Watts Dict. 1. 1042. (4) Ann. Chim. Phys. 44. 387. Gmelin-Kraut 3. 638. Watt. Dict. 2. 52. (5) Pogg. Ann. 55. 246. Gmelin-Kraut 3. 638. Watts Dict. 2. 52. (6) Ros. and Sch. 2. 1. 336. (7) Gmelin-Kraut 3. 638. (8) Ann. Chim. Phys. 44. 385. Gmelin-Kraut 3. 638.

† (1) Watts Dict. 2. 52. (2) Gmelin-Kraut 3. 353. Ros. and Sch. 2. 2. 100. (3) Gmelin-Kraut 3. 352. (4) Ann. Chim. Phys. 44. 392. (5) Chem. Soc. J. 33. 273. (6) Pogg. Ann. 8. 330. Gmelin-Kraut 3. 245. Ros. and Sch. 2. 1. 287.

fies to a white horny mass, Löwig (7) ; but by fusion in the air it emits white fumes and leaves a pearly yellow residue of the oxy-bromide, Balard\* (1).

*Magnesium Bromide.  $MgBr_2$ .*

Anhydrous magnesium bromide melts at  $695^\circ$ , T. Carnelley (2) or is not fusible below a red heat and is not volatile, H. Serullas (3). The crystallized salt ( $MgBr_2 \cdot 6H_2O$ ) is decomposed when heated in the air into hydro-bromic acid and oxide of magnesium, Balard (4).

*Manganous Bromide.  $MnBr_2$ .*

Crystallized manganous bromide ( $MnBr_2 \cdot 2H_2O$ ), when carefully heated in a closed vessel, gives off its water of crystallization and leaves the anhydrous bromide (5), and this when ignited in contact with the air, gives off bromine vapors and leaves manganoso-manganic oxide (6). The salt containing 4 mol. of water ( $MnBr_2 \cdot 4H_2O$ ) melts in its water of crystallization when heated, and then becomes anhydrous, melting again at a white heat, at which temperature it decomposes completely in contact with the air into bromine and oxide of manganese. Berthémot† (1).

*Mercuric Bromide.  $HgBr_2$ .*

Mercuric bromide melts at  $222-223^\circ$ , Oppenheim (2) or at  $244^\circ$ , T. Carnelley (3), and sublimes, Balard (4), Löwig (5) (6), boiling at  $319^\circ$ , T. Carnelley and W. C. Williams (7).

*Mercurous Bromide.  $Hg_2Br_2$ .*

Mercurous bromide is fusible, O. Henry (8), or is not fusible, and volatilizes undecomposed at  $405^\circ$ , T. Carnelley (3) or at a low red heat, Löwig (9).

*Nickelous Bromide.  $NiBr_2$ .*

Nickelous bromide, when heated to strong redness out of contact

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Miller 638. (7) Gmelin-Kraut 3. 245. Watts Dict. 3. 538. Ros. and Sch. 2. 1. 287.

\* (1) Pogg. Ann. 8. 330. Gmelin-Kraut 3. 245. Watts Dict. 3. 538. Ros. and Sch. 2. 1. 287. (2) Chem. Soc. J. 33. 273. (3) Ann. Chim. Phys. 48. 87. Pogg. Ann. 24. 348. J. Chim. med. 8. 4. Gmelin-Kraut 2. 1. 466. (4) Pogg. Ann. 8. 330. Gmelin-Kraut 2. 1. 466. Watts Dict. 3. 752. Ros. and Sch. 2. 1. 242. (5) Watts Dict. 3. 803. (6) Gmelin-Kraut 2. 2. 493.

† (1) Ann. Chim. Phys. 44. 392. Gmelin-Kraut 2. 2. 493. (2) Clark's Constants of Nature. (3) Chem. Soc. J. 33. 273. (4) Pogg. Ann. 8. 331. Gmelin-Kraut 3. 778. Watts Dict. 3. 892. (5) Gmelin-Kraut 3. 778. (6) Ros. and Sch. 2. 1. 405. (7) Chem. Soc. J. 33. 281. (8) J. Ph. Chim. 15. 56. Gmelin-Kraut 3. 778. Watts Dict. 3. 892. (9) Gmelin-Kraut 3. 778. Watts Dict. 3.

with air, sublimes in golden scales ; but if air be admitted it decomposes into bromine vapor and nickelous oxide, Berthelot (10). The crystallized salt ( $\text{NiBr}_2 \cdot 3\text{H}_2\text{O}$ ) loses its water at  $200^\circ$ , C. Rammelsberg\* (1).

*Potassium Bromide KBr.*

Potassium bromide decrepitates in the fire, Balard (2), melts at  $699^\circ$ , T. Carnelley (3), or at  $703^\circ$ , T. Carnelley (4), without decomposition, Balard (2), and solidifies again at  $685^\circ$ , T. Carnelley (5).

*Silver Bromide AgBr.*

Silver bromide melts at  $380^\circ$ , G. F. Rodwell (6), at  $427^\circ$ , T. Carnelley (3), or at  $434^\circ$ , T. Carnelley (4) to a reddish liquid, which on cooling congeals to a yellow translucent horny mass, Balard (7).

*Sodium Bromide NaBr.*

Sodium bromide melts at  $708^\circ$ , T. Carnelley (3), or, at  $712^\circ$ , T. Carnelley (4). The crystallized salt ( $\text{NaBr} \cdot 2\text{H}_2\text{O}$ ) melts in the heat, losing its water and becoming anhydrous, Mitscherlich (8).

*Stannic Bromide. SnBr<sub>4</sub>.*

Stannic bromide melts easily, Balard† (1), at  $30^\circ$ , and boils without decomposition at  $201^\circ$  (uncorr), at which temperature it sublimes, T. Carnelley and L. T. O'Shea (2), in the form of needles (3) ; but at a gentle heat in the air it gives off white vapors, Balard (4), which consist of the oxide of tin, T. Carnelley and L. T. O'Shea (5).

*Stannous Bromide. SnBr<sub>2</sub>.*

Stannous bromide melts at  $259^\circ$ , T. Carnelley and W. C. Williams (6), to a yellowish oily liquid (3), which boils at  $617\text{--}634^\circ$ , T. Carnelley and W. C. Williams (6). When the salt is heated in the air it evolves stannic bromide and leaves stannic oxide behind (3).

*Strontium Bromide. SrBr<sub>2</sub>.*

Strontium bromide melts at  $630^\circ$ , T. Carnelley (7), or at a red

892. Ros. and Sch. 2. 1. 400. (10) Ann. Chim. Phys. 44. 382. J. Ph. Chim. 16. 655. Gmelin-Kraut, 8. 552. Ros. and Sch. 2. 2. 150.

\* (1) Pogg. Ann. 55. 343. (2) Pogg. Ann. 8. 327. Gmelin-Kraut, 2. 2. 69. Watts Dict. 4. 696. (3) Chem. Soc. J. 33. 273. (4) Chem. Soc. J. 29. 489. Zeitsch. Anal. Chem. 17. 469. (5) Chem. Soc. J. 29. 499. (6) Proc. Roy. Soc. 25. 280. (7) Pogg. Ann. 8. 332. Gmelin-Kraut 3. 936. Ros. and Sch. 2. 1. 373. (8) Pogg. Ann. 17. 385. Gmelin-Kraut. 2. 1. 202.

† (1) Pogg. Ann. 8. 331. Gmelin-Kraut 3. 124. Watts Dict. 5. 806. (2) Chem. Soc. J. 33. 56. Ros. and Sch. 2. 2. 249. (3) Gmelin-Kraut 3. 124. Watts Dict. 5. 808. (4) Pogg. Ann. 8. 331. Gmelin-Kraut 3. 124. (5) Chem. Soc. J. 33. 56. (6) Chem. Soc. J. 35. 563. Ber. 12. 1360. (7) Chem. Soc. J.

heat without decomposition, Berthemot (8), C. Rammelsberg (9). The crystallized salt ( $\text{SrBr}_2 \cdot 6\text{H}_2\text{O}$ ), when heated, melts without decomposition in its water of crystallization, C. Rammelsberg\* (1) Berthemot (2), which it loses at a gentle heat, Löwig (3).

*Zinc Bromide.  $\text{ZnBr}_2$ .*

Zinc bromide melts at  $394^\circ$ , T. Carnelley (4), to a yellow liquid, Löwig (5), which boils at  $695\text{--}699^\circ$ , T. Carnelley and W. C. Williams (6), and sublimes in the form of white needles, Löwig (7), or passes over in the form of white vapors, Berthemot (8).

THE CHLORIDES.

*Aluminium Chloride.  $\text{Al}_2\text{Cl}_6$ .*

Aluminium chloride in small quantities volatilizes in the heat without melting; a large amount, however, when strongly and rapidly heated, melts and then boils, the vapors condensing between  $180$  and  $185^\circ$ , Liebig† (1). The salt is fusible, F. Wöhler (2), boils at  $180\text{--}185^\circ$ , (Liebig) Weber (3), and its point of volatility seems to coincide with its melting point, Wöhler (4), or is not much higher than the boiling point of water, (Oersted) Wöhler (2). The crystallized salt containing 12 mol. of water ( $\text{Al}_2\text{Cl}_6 \cdot 12\text{H}_2\text{O}$ ) loses when heated, water and hydrochloric acid without previously undergoing fusion, and leaves a residue of aluminium oxide, v. Bonsdorff (5.)

*Ammonium Chloride.  $\text{NH}_4\text{Cl}$ .*

Ammonium chloride, when heated, volatilizes undecomposed without previous fusion (6), forming after sublimation white crystalline masses (7), or a fibrous mass of crystalline structure, J. M. Maisch (8). The salt is decomposed on vaporization, L. Pebal

33. 275. (8) Ann. Chem. Phys. 44. 395. Gmelin-Kraut 2. 1. 334. Watts Dict. 5. 436. (9) Pogg. Ann. 55. 238. Gmelin-Kraut 2. 1. 334. Watts Dict. 5. 436.

\* (1) Pogg. Ann. 55. 238. Gmelin-Kraut 2. 1. 334. Watts Dict. 5. 436. (2) Ann. Chim. Phys. 44. 395. (3) Mag. der Pharm. 33. 7. Gmelin-Kraut 2. 1. 334. (4) Chem. Soc. J. 33. 278. (5) Gmelin-Kraut 3. 29. (6) Chem. Soc. J. 33. 281. Chem. News. 37. 212. Dingl. polyt. J. 230 449. Jahresb. 31. 36. (7) Gmelin-Kraut 3. 29. Watts Dict. 5. 1069. Ros. and Sch. 2. 1. 261. (8) Ann. Chim. Phys. 44. 389.

† (1) Annalen 17. 43. Gmelin-Kraut 2. 1. 644. Watts Dict. 1. 157. Ros. and Sch. 2. 1. 447. (2) Pogg. Ann. 11. 151. (3) Pogg. Ann. 103. 259. Chem. Gaz. 16. 269. (4) Pogg. Ann. 11. 150. Miller 429. (5) Pogg. Ann. 27. 279. Gmelin-Kraut 2. 1. 644. Ros. and Sch. 2. 1. 447. (6) Gmelin, Watts Transl. 2, 478. Watts Dict. 1. 191. Miller 392. (7) Watts Dict. 1. 191. (8) Amer J.

(9), or is not decomposed, Deville (10). When the salt is heated in a bright platinum dish, it volatilizes without browning and without leaving a residue, Karl Seubert (1).\*

*Antimonic Chloride.  $SbCl_3$ .*

Antimonic chloride solidifies only in a freezing mixture, forming needle-shaped crystals, which melt, at  $-6^\circ$ , F. Kammerer (2), volatilize easily, and which on distillation partially decompose into chlorine and antimonous chloride (3).

*Antimonous Chloride.  $SbCl_3$ .*

Antimonous chloride melts at  $72^\circ$ , J. P. Cooke (4), Capitaine (5), or at  $73.2^\circ$ , Kopp (6), boils at  $197.8^\circ$ , Davy (7), at  $200^\circ$  (8), at  $216^\circ$  J. P. Cooke (9), at  $221^\circ$  T. Carnelley and W. C. Williams (10), at  $223^\circ$ , Kopp (11), or at  $230^\circ$  Capitaine (12), and can be distilled in a retort at a temperature above that required to distill hydrochloric acid (1).†

*Arsenious Chloride.  $AsCl_3$ .*

Arsenious chloride does not solidify even at  $-29^\circ$ , J. Davy (2), and boils at  $128^\circ$ , Haagen (3), at  $130.21^\circ$ , T. E. Thorpe (4), at  $132^\circ$ , Dumas (5), or at  $134^\circ$ , Pierre (6).

*Barium Chloride.  $BaCl_2 \cdot 2H_2O$ .*

Crystallized barium chloride with 2 mol. of water loses 1 mol.

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Pharm. 32. 522. Chem. News. 8. 96. (9) Amer J. Pharm. 30. 54. Ros. and Sch. 2. 1. 176 (10) Jahresb. 16. 87. Ros. and Sch. 2. 1. 176.

\* (1) Annalen. 207. 10. (2) Ber. 8. 517. Amer. Chem. 6. 112. Ros. and Sch. 2. 318. (3) Ros. and Sch. 2. 2. 318. (4) Proceed. Amer. Acad. New Series. 5. Ber. 11. 255. Jahresb. Ph. Tox. 1878. 259. Jahresb. 30. 284. Watts Dict. 1. 818. Ros. and Sch. 2. 2. 316. (5) J. pr. Chem. 18. 449. J. Ph. Chim. 25. 516. Gmelin. Watts Transl. 4. 366. Ros. and Sch. 2. 2. 316. (6) Annalen 94. 257. Pharm. Centr. 1855. 771. Jahresb. 8. 37. (7) Gilb. Ann. 49. 357. Gmelin. Watts Trans. 4. 366. (8) Watts Dict. 1. 318. (9) Proceed. Amer. Acad. New Series. 5. Ber. 11. 255. Jahresb. Ph. Tox. 1878. 259. Jahresb. 30. 284. (10) Chem. Soc. J. 33. 281. (11) Annalen. 94. 257. Pharm. Centr. 1855. 771. Jahresb. 8. 37. Ros. and Sch. 2. 2. 316. Miller 600. (12) J. pr. Chem. 18. 449. J. Ph. Chim. 25. 516. Gmelin. Watts Transl. 4. 336.

† (1) Ros. and Sch. 2. 2. 316. (2) Gmelin. Watts Transl. 4. 284. Watts Dict. 1. 371. Ros. and Sch. 1. 522. (3) Pogg. Ann. 181. 117. (4) Chem. Soc. J. 37. 352. (5) Ann. Chim. Phys. 38. 337. Pogg. Ann. 9. 315. Annalen 93. 277. Watts. Dict. 1. 371. Gmelin. Watts Transl. 4. 284. Miller 586. (6) Compt. rend. 27. 213.



at 56°, Mulder (7), and becomes anhydrous at 100° (8), at 113° (9), or at 121°, Mulder (7). The an-hydrous salt melts at a full red heat (10) and when fused in the air it loses chlorine and becomes alkaline under the formation of baryta, E. Kraus (11). Dumas (1),\* Marignac (2). When the salt is heated in a glass at the highest temperature that the glass can bear, it neither melts nor decomposes, Edward Kraus (3).

*Bismuth Chloride.  $\text{BiCl}_3$ .*

Bismuth chloride melts at 225–230°, M. P. Muir (4), forming an oily liquid, J. Davy (5), which boils at 427–439°, T. Carnelley and W. C. Williams (6), volatilizes at a moderate heat, H. Davy (5), and sublimes in the form of beautiful crystals, M. P. Muir (7). When the salt is distilled in vessels containing air it yields a small quantity of oxychloride of bismuth in the form of micaceous laminae, Jacquelin (5).

*Cadmium Chloride.  $\text{CdCl}_2 \cdot 2\text{H}_2\text{O}$ .*

Cadmium chloride with 2 mol. of water of crystallization melts when heated and yields the anhydrous salt, Stromeyer (1),† which fuses at 541°, T. Carnelley (2), boils above 861° T. Carnelley and W. C. Williams (3), and on cooling forms a transparent laminated pearly mass, and which at a more elevated temperature sublimes in the form of transparent micaceous plates, Stromeyer (1).

*Calcium Chloride.  $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$ .*

Calcium chloride with 6 mol. of water melts at 28.5°, Person (4),

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Pogg. Ann. 76. 458. Ros. and Sch. 1. 522. (7) Gmelin-Kraut. 2. 1. 300. (8) Watts Dict. 1. 502. (9) Ros. and Sch. 2. 1. 223. (10) Gmelin-Kraut. 2. 1. 300. Watts Dict. 1. 502. Ros. and Sch. 2. 1. 223. (11) Pogg. Ann. 43. 140. Berzelius' Jahresb. 19. 234. Gmelin-Kraut. 2. 1. 300. Ros. and Sch. 2. 1. 223.

\* (1) Gmelin-Kraut. 2. 1. 300. (2) Recherch. 13. Jahresb. 8. 842. Gmelin-Kraut. 2. 1. 300. (3) Pogg. Ann. 43. 140. (4) Chem. Soc. J. 29. 144. Chem. News. 82. 277. Jahresb. 29. 264. Ros. and Sch. 2. 2. 336. (5) Gmelin. Watts Transl. 4. 438. (6) Chem. Soc. J. 33. 281. Chem. News. 37. 212. Dingl. pol. J. 230. 440. Jahresb. 31. 36. (7) Chem. Soc. J. 29. 144. Jahresb. 29. 264. Ros. and Sch. 2. 2. 336.

† (1) Ann. Chim. Phys. 11. 81. Gmelin-Kraut. 3. 72. Watts Dict. 1. 703. Ros. and Sch. 2. 1. 267. (2) Chem. Soc. J. 33. 273. (3) Chem. Soc. J. 33. 281. (4) Compt. rend. 23. 162. Ann. Chim. Phys. [3] 27. 250. Pogg. Ann. 70. 300. Annalen 64. 179. Instit. 1846. 247. Comp. rend. 29. 300. Jahresb. 1. 72. 2. 33

at 29°, Herman Kopp (5), at or near 34°, Mulder (6), loses 4 mol. at 200° Mitscherlich (7), at 150° if the heat be prolonged (8), or after 12 days in a vacuum in the heat of the sun (9), and becomes anhydrous at a more elevated temperature (10), or at 130° in dry air, losing at the same time a trace of its acid, H. C. Dibbitts (1).<sup>\*</sup> The anhydrous salt melts at 719°, T. Carnelley (2), or at 723°, T. Carnelley (3), and when subjected for 10 minutes to a white heat, one portion is converted into calcium oxide, another portion is left undecomposed in the residue, while still another portion is volatilized unchanged, Al. Mitscherlich (4). When the salt is ignited in the air, a small portion is converted into the oxide, Edward Kraus (5), Liebig (6) or into the oxide and carbonate of calcium (7).

*Chromium Chloride Cr<sub>2</sub>Cl<sub>6</sub>.*

Hydrated chloride of chromium loses water and acid at 170°, and at 200° there remains a green mass, which with water yields a dark green solution, in which is found a light blue, and a dark red, powder, the former of which has the composition of Cr<sub>2</sub>O<sub>3</sub> + 3Cr<sub>2</sub>Cl<sub>6</sub>, the latter Cr<sub>2</sub>O<sub>3</sub> + 2Cr<sub>2</sub>Cl<sub>6</sub>, Moberg (8). The anhydrous salt, when heated to redness in the air, yields the green chromium oxide, H. Rose (1) † Wöhler (2); but when heated in a sealed porcelain crucible in a reverberatory furnace at almost the melting point of the crucible, it on removal consists of green chromium chloride, and some peach-blossom colored needles, which are attached to the sides of the crucible, H. Gaultier de Claubry (3). When the hydrated chloride of chromium is heated in a closed vessel at 300°, or a little below an incipient redness, it is converted into the violet insoluble sesqui-chloride, Henry Loewell (4).

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Gmelin-Kraut. 2. 1. 396. (5) Annalen 93. 206. Instit. 1855. 260. Phil. Mag. J. [4] 9. 477. Pharm. Centr. 1855. 219. Jahresb. 8. 44. Gmelin-Kraut. 2. 1. 396. Ros. and Sch. 2. 1. 192. Miller 415. (6) Gmelin-Kraut 2. 1. 396. (7) Gmelin-Kraut. 2. 1. 396. Ros. and Sch. 2. 1. 192. (8) Miller 415. (9) Annalen 29. 31. Gmelin-Kraut. 2. 1. 396. (10) Ros. and Sch. 2. 1. 192.

<sup>\*</sup> (1) Arch. néerland 13. 478. Jahresb. 32. 132. (2) Chem. Soc. J. 33. 273. (3) Chem. Soc. J. 29. 489. Zeitschr. Anal. Chem. 17. 469. (4) J. pr. Chem. 83. 485. Zeitschr. Anal. Chem. 1. 63. Jahresb. 14. 843. Gmelin-Kraut, 2. 1. 393. (5) Pogg. Ann. 43. 139. Gmelin-Kraut. 2. 1. 393. (6) Gmelin-Kraut. 2. 1. 393. (7) Watts Dict. 1. 718. (8) Berzelius' Jahresb. 23. 229. Annalen 48. 229.

† (1) Read at Berlin Academy, Oct. 15. J. pr. Chem. 16. 214. Gmelin-Kraut. 2. 2. 315. Watts Dict. 1. 942. Ros. and Sch. 2. 2. 163. (2) Phil. Mag. J. [4] 18. 456. (3) Ann. Chim Phys. 45. 110. (4) Ann. Chim. Phys. [3]

*Cobaltous Chloride,  $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ .*

Crystallized cobaltous chloride with 6 mol. of water melts at  $86.7^\circ$  to a blue liquid, which begins to boil at  $111^\circ$ , and which at  $116^\circ$  loses 2 mol., and at  $121^\circ$  4 mols., yielding a dark crystalline powder of the composition of  $\text{CoCl}_2 \cdot 2\text{H}_2\text{O}$ , which at a temperature higher than  $140^\circ$  becomes anhydrous, Bersch (5). The anhydrous salt, when strongly heated, melts and sublimes, Proust (1), or sublimes without melting, Fellenberg (1).\*

*Cupric Chloride.  $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$ .*

Cupric chloride with 2 mol. of water melts at a gentle heat, Proust (2), becomes brown at  $100^\circ$  under evolution of most of its water, but loses the whole only at  $200^\circ$ , Graham (3), even at  $101^\circ$ , A. Vogel (4), or begins to give off water slowly at  $90^\circ$ , and when heated more strongly yields the oxide of copper, J. H. Gladstone (5). The anhydrous chloride melts at  $498^\circ$ , T. Carnelley (6), or at a red heat under the evolution of  $\frac{1}{2}$  of its chlorine and forms thereby the cuprous salt, H. Rose (7). Even at an incipient redness the salt is decomposed, the reaction being represented by the following equation,  $3\text{CuCl}_2 = \text{Cu}_2\text{Cl}_2 + \text{CuCl}_2 + 2\text{Cl}$ , A. Vogel (8). At  $205^\circ$  cupric chloride is converted into cuprous chloride and metallic copper, John Davy (9).

*Cuprous Chloride  $\text{Cu}_2\text{Cl}_2$ .*

Cuprous chloride melts at  $434^\circ$ , T. Carnelley (1),† or at a temperature a little below an incipient redness to a yellow liquid, which is not decomposed at a strong red heat in closed vessels, but which, if air be freely admitted, is dissipated in the form of white fumes, John Davy (2). The salt, when heated between  $100^\circ$  and  $200^\circ$  in a

15. 48. (5) Wien. Akad. Ber. [2] 56. 724. J. pr. Chem. 103. 253. Zeitschr. Chem. 1868. 574. Chem. Centr. 1868. 332. Jahresb. 20. 29. Gmelin-Kraut. 3. 456. Ros. and Sch. 2. 2. 130.

\* (1) Gmelin-Kraut 3. 455. (2) Gmelin-Kraut 3. 642. (3) Annalen 29. 31. Gmelin-Kraut 3. 642. Watts Dict. 2. 52. (4) Dingl. pol. J. 136. 239. Jahresb. 8. 413. Gmelin-Kraut 3. 642. (5) Chem. Soc. J. 8. 212. Jahresb. 8. 414. (6) Chem. Soc. J. 33. 278. (7) Gmelin-Kraut 3. 642. Watts Dict. 2. 52. Ros. and Sch. 2. 1. 334. Müller 621. (8) Gmelin-Kraut 3. 642. (9) Phil. Trans. 1812. 169. J. pr. Chem. 66. 376. Abstracts of Phil. Trans. of Roy. Soc. 1. 425.

† (1) Chem. Soc. J. 33. 273. (2) Phil Trans. 1812. 169. Abstracts to Phil.

stream of moist air, changes very quickly into an oxy-chloride, Millet (3).

*Ferric Chloride  $Fe_2Cl_6H_2O$ .*

Crystallized ferric chloride with 6 mol. of water melts at  $31^\circ$ , Ordway (4), or melts easily and congeals again at  $42^\circ$ , Fritzsche (5). The anhydrous salt is volatile, John Davy (6) at somewhat over  $100^\circ$  and sublimes, forming large hexagonal tablets, Deville and Troost (7).

*Ferrous Chloride  $FeCl_2$ .*

Ferrous chloride melts at a red heat and volatilizes above the melting point of glass, John Davy (1).<sup>\*</sup> When the salt is heated with a moderate admission of air, ferric chloride sublimes and ferrous oxide is left behind (2); but in the open air chlorine escapes and peroxide of iron remains (3).

*Lead Chloride  $PbCl_2$ .*

Lead chloride melts at  $498^\circ$  T. Carnelley, (4), at  $524^\circ$  T. Carnelley (5), or at  $580^\circ$ , Braun (6), and boils above  $861^\circ$ , T. Carnelley and W. C. Williams (7), forming on cooling a translucent white horny mass (8). Chloride of lead does not volatilize at a strong red heat if the air be excluded, J. Davy (9), or it may be sublimed though with difficulty (10); but when heated in the air it gives off vapors and leaves the oxychloride, Döbereiner (11).

*Magnesium Chloride  $MgCl_2 \cdot 6H_2O$ .*

Crystallized magnesium chloride with 6 mol. of water begins to lose acid at  $106^\circ$ , is semi-liquid at  $112^\circ$  and entirely melted at  $119^\circ$ ,

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Trans. of Roy. Soc. 1. 425. Gmelin-Kraut 3. 640. Watts Dict. 2. 54. (3) Compt. rend. 66. 349. Jahresb. 19. 125. Gmelin-Kraut 3. 641. (4) Amer. J. Sci. [2] 40. 829. Zeitschr. Chem. 1868. 23. Jahresb. 18. 262. (5) J. pr. Chem. 18. 479. Gmelin-Kraut 3. 357. (6) Phil. Trans. 1812. 169. Abstracts to Phil. Trans. of Roy. Soc. 1. 425. Miller 520. (7) Compt. rend. 45. 831. Jahresb. 10. 224. Gmelin-Kraut 3. 356. Watts Dict. 3. 377. Ros. and Sch. 2. 2. 98.

<sup>\*</sup> (1) Schw. 10. 326. Gmelin-Kraut 3. 355. Watts Dict. 3. 376. Ros. and Sch. 2. 2. 92. Miller 520. (2) Gmelin-Kraut 3. 354. Watts Dict. 3. 376. Ros. and Sch. 2. 2. 92. (3) Miller 520. (4) Chem. Soc. J. 33. 273. (5) Chem. Soc. J. 21. 881. Zeitschr. Anal. Chem. 19. 175. (6) Pogg. Ann. 154. 190. (7) Chem. Soc. J. 33. 281. 35, 563. Ber. 12. 1360. (8) Gmelin-Kraut 3. 246. Watts Dict. 3. 538. Ros. and Sch. 2. 1. 286. (9) Gmelin-Kraut 3. 246. (10) Watts Dict. 3. 538. (11) Schw. 17. 255. Gmelin-Kraut 3. 246. Watts Dict. 3. 538. Ros. and Sch. 2. 1. 286.

Brandes (1),\* and changes under loss of water and hydrochloric acid into a mixture of magnesia and a little chloride of magnesium, H. Davy (2), or into pure magnesia (3). The crystallized salt loses 5 mol. of water when heated in dry air at  $100^{\circ}$ . A four hours heating at  $100\text{--}130^{\circ}$  causes a slight loss of acid, about 0.1 per cent., and only after 4 hours at  $180^{\circ}$  is the loss equivalent to 6 mol. of water; but even then the salt cannot be anhydrous, for some of the loss is due to the acid expelled, Dibbits (4). The anhydrous salt melts below a red heat (5), or at a red heat (6) or at  $708^{\circ}$ , T. Carnelley (7), and suffers a temperature at redness in dry air without decomposition, but with moisture present it decomposes into magnesia and hydrochloric acid, Gay-Lussac and Thenard (8) H. Kunheim (9). When magnesium chloride is heated by itself it changes into magnesia, containing however, an unweighable amount of chlorine, M. Kretschy (1).†

*Manganic Chloride.  $Mn_2Cl_6$ .*

Manganic Chloride, when heated, is converted into chlorine and manganous chloride,  $Mn_2Cl_6 = 2MnCl_2 + Cl_2$  (2).

*Manganous Chloride.  $MnCl_2 \cdot 4H_2O$ .*

Manganous chloride with 4 mol. of water becomes white and opaque at  $25^{\circ}$ , gives off hygroscopic water between  $25^{\circ}$  and  $37^{\circ}$ , at  $37.5^{\circ}$  becomes tough; at  $50^{\circ}$  semi-liquid; at  $87.5^{\circ}$  it fuses, forming a mobile liquid, which boils at  $106^{\circ}$ , John (3); and if kept near  $100^{\circ}$  for some time, it loses 28 per cent. of its water, retaining 1 mol., Brandes (3). At the last named temperature the salt appears to lose hydrochloric acid and to be partially transformed into the insoluble chloride, Krecke (4). The anhydrous chloride of manganese melts to an oily liquid at a dull red heat (5), but does not volatilize at a temperature under the melting point of glass, R. Fresenius (6), or on the other hand it does volatilize even at a red

\* (1) Br. Arch. 12. 195. Gmelin-Kraut 2. 1. 468. (2) Gmelin-Kraut 2. 1. 468. (3) Ros. and Sch. 2. 1. 241. (4) Jahresb. Ph. Tox. 1877. 279. (5) Watts Dict. 3. 752. (6) Miller 452. (7) Chem. Soc. J. 33. 273. (8) Recherch. 2. 143. Gmelin-Kraut 2. 1. 467. (9) Jahresb. 14. 149. Gmelin-Kraut 2. 1. 467.

† (1) Zeitschr. Ann. Chem. 15. 57. (2) Miller 549. (3) Gmelin-Kraut 2. 2. 495. Watts Dict. 3. 804. (4) J. pr. Chem. 113. 105. Gmelin-Kraut 2. 2. 496. (5) Gmelin-Kraut 2. 2. 495. Watts Dict. 3. 804. Ros. and Sch. 2. 2. 6. (6) Zeitschr. Anal. Chem. 11. 424. Gmelin-Kraut 2. 2. 495. Watts Dict. 3. 804.

heat, Wright and Menke (1).<sup>\*</sup> The salt is not decomposed at a red heat if air be excluded; but when ignited in an open crucible hydrochloric acid is evolved and oxide of manganese remains, John Davy (2), or manganoso-manganic oxide (3).

*Mercuric Chloride.  $HgCl_2$ .*

Mercuric chloride melts at 254° (4), at 265° (5), at 288°, T. Carnelley (6), or at 302°, T. Carnelley (7), boils at 295° (8), or at 303°, T. Carnelley and W. C. Williams (9), and volatilizes somewhat more easily than calomel (10). Mercuric chloride sublimes at or near 93.3° leaving no residue, W. A. Guy (11).

*Mercurous Chloride.  $Hg_2Cl_2$ .*

Mercurous chloride volatilizes at 138° without previously melting and leaving a residue, Wm. A. Guy (11), volatilizes below a red heat (12), does not decompose into metallic mercury and mercuric chloride at 440°, as shown by the fact that gold leaf does not lose its brightness or its ductility, when brought in contact with vapors of calomel, Debray (1),<sup>†</sup> but does decompose at that temperature, for a cold silver tube, when brought in contact with the vapors, is covered over with a film of mercury, Debray (2). When calomel is sublimed a small portion is always converted into metallic mercury and corrosive sublimate, Erlenmeyer (3), Deville and Troost (4). Gold leaf forms an amalgam in the vapor of calomel, Odling (5).

*Nickelous Chloride.  $NiCl_2$ .*

Nickelous chloride sublimes in a vacuum without decomposition; but when strongly heated in a retort the sublimation occurs under the evolution of some chlorine, and the formation of some nickelous oxide, Otto Linne Erdmann (6).

<sup>\*</sup> (1) Chem. Soc. J. 37. 28. Gmelin-Kraut 2. 2. 495 (2) Phil. Trans. 1812. 169. Abstracts to Phil. Trans. of Roy. Soc. 1. 425. (3) Watts Dict. 3. 804. Ros. and Sch. 2. 2. 6. (4) Miller 656. (5) Watts Dict. 3. 897. (6) Chem. Soc. J. 33. 273. (7) Chem. Soc. J. 29. 489. Zeitschr. Anal. Chem. 17. 469. (8) Watts Dict. 3. 897. Miller 656. (9) Chem. Soc. J. 33. 281. (10) Gmelin-Kraut 3. 788. Watts Dict. 3. 897. Ros. and Sch. 2. 1. 404. (11) Pharm. J. Trans. 1868. 370. Amer. J. Pharm. 40. 246. Jahresb. Ph. Tox. 1868. 562. (12) Ros. and Sch. 2. 1. 399. Watts Dict. 3. 895.

<sup>†</sup> (1). Compt. rend. 66. 1339. Instit. 1868. 210. Zeitsch. Chem. 1868. 543. J. pr. chem. 107. 254. Amer. J. Sci. [2] 46. 398. Ber. 9. 1443. Jahresb. 21. 271. Gmelin-Kraut 3. 783. (2) Compt. rend 83. 330. Ber. 9. 1443. Jahresb. Ph. Tox. 1876. 308. Ros. and Sch. 2. 1. 400. (3) Annalen 131. 124. Jahresb. 17. 280. Gmelin-Kraut 3. 783. Ros. and Sch. 2. 1. 400. Miller 655. (4) Ros. and Sch. 2. 1. 400. (5) Jahresb. 17. 280. Gmelin-Kraut 3. 783. (6) J. pr. chem. 7. 251. Gmelin-Kraut 3. 553. Ros. and Sch. 2. 2. 150.

*Potassium Chloride. KCl.*

Potassium chloride decrepitates in the heat (1)\* melts at 730°, Braum (2), at 734°, T. Carnelley (3), at 770° T. Carnelley (4), or at a low red heat (5), and volatilizes unchanged at strong redness (6), losing some in weight even by melting, Stas (7). 1. 0255 grams of the salt, when subjected to a red heat for 8 hours, lost 0.1735 gram, H. Rose (8). 2. 6225 grams was entirely volatilized after a 6 minute heating at dark redness, A. Mitscherlich (9). For comparison of the volatility of potassium chloride with that of sodium chloride, see Bunsen (10).

*Silver Chloride. AgCl.*

Silver chloride when heated assumes a yellow color (11), melts at 260° (12), at 350°, G. F. Rodwell (13) at 451°, T. Carnelley (3), or 457°, T. Carnelley (14), to a translucent orange yellow liquid (1),† and vaporizes undecomposed at a higher temperature (2). Silver chloride will endure a temperature of 150° without loss, if light, and organic matter be excluded; and if a portion of this dry chloride be heated in a test tube, it loses a part of its acid, sufficient to redden litmus, but the loss does not reach an appreciable quantity, Dr. Turner (3).

*Sodium Chloride. NaCl.*

Sodium chloride decrepitates when heated, Karsten (4), T. Carnelley (5), melts at 772°, T. Carnelley (6), at 776°, T. Carnelley (5) at 960°, Braun (7), or at a red heat (8), crystallizing on cooling (9) It volatilizes somewhat at its melting point, Stas (10), at a tempera-

\* (1) Gmelin-Kraut 2. 1. 73. Watt's Dict. 4. 697. (2) Pogg. Ann. 154. 190. (4) Chem. Soc. J. 31. 381. Zeitschr. Anal. Chem. 19. 175. (3) Chem. Soc. J. 33. 273. (5) Watt's Dict. 4. 697. (6) Gmelin-Kraut 2. 1. 73. Watt's Dict. 4. 697. Ros. and Sch. 2. 1. 68. (7) Gmelin-Kraut 2. 1. 73. (8) Pogg. Ann. 31. 133. (9) J. pr. Chem. 83. 485. Zeitsch. Anal. Chem. 1. 63. (10) Annalen 138. 264. Zeitsch. Anal. Chem. 5. 351. Phil. Mag. J. [4] 32. 81. Jahresb. 19. 766. (11) Gmelin-Kraut 3. 942. Ros. and Sch. 2. 1. 370. (12) Gmelin-Kraut 3. 942. Watt's Dict. 5. 296. Ros. and Sch. 2. 1. 370. Miller 684. (13) Proc. Roy. Soc. 25. 280. (14) Chem. Soc. J. 39. 489. Zeitschr. Anal. Chem. 17. 469.

† (1) Gmelin-Kraut 3. 942. Ros. and Sch. 2. 1. 370. (2) Gmelin-Kraut 3. 942. (3) Phil. Trans. 1833. pr. 2 p 534. Phil. Mag. J. [3] 4. 397. (4) Gmelin-Kraut 2. 1. 205. (5) Chem. Soc. J. 29. 489. Zeitschr. Anal. Chem. 17. 469. (6) Chem. Soc. J. 33. 273. (7) Chem. Soc. J. 28. 31. (8) Gmelin-Kraut 2. 1. 205. Watt's Dict. 5. 336. (9) Watt's Dict. 5. 336. Ros. and Sch. 2. 1. 113. (10) Gmelin-

ture above its melting point, T. Carnelley (5), at a low red heat in an open vessel, H. Rose (11), or at a white heat even in closed vessels (11), but cannot be decomposed, Edward Kraus (12). A small quantity of the salt lost 62 per cent. of its weight when heated for 15 minutes at a strong red heat, A. Mitscherlich (13). 1.016 grams, when subjected to a red heat in a small platinum crucible, losses .07745 gram, H Rose (1).<sup>\*</sup> For comparison of its volatility with that of other salts, see Bunsen (2).

*Stannic Chloride  $\text{SnCl}_4$ .*

Stannic chloride with 3 mol. of water melts at 80° and on cooling solidifies to a crystalline mass; at a stronger heat it evolves water and hydrochloric acid and leaves stannic oxide behind, Casselmann (3). The salt with 5 mol. of water melts at a low temperature, and on cooling again solidifies to a crystalline mass, Gerlach (4). The anhydrous salt does not solidify at -29°, Dumas (5), boils at 113.9°, Thorpe (6), at 112.5°, Andrews (7), at 115.4°, Pierre (8), at 120°, Dumas (9), or at 162°, Haagen (10).

*Stannous Chloride.  $\text{SnCl}_2$ .*

Stannous chloride crystallized with 2 mol. of water melts at 37.7-40.5° and crystallizes very easily on cooling, Penny (1); † but when more strongly heated it loses water and hydrochloric acid, which contains some metallic tin, and leaves stannous chloride and oxide behind (2). The salt with 3 mol. of water melts at 80°, solidifying again on cooling, and at a stronger heat loses water and hydrochloric acid, while stannic oxide remains behind, W. Cassel-

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Kraut 2. 1. 205. Ros. and Sch. 2. 1. 113. (11) Watt's Dict. 5. 336. (12) Pogg. Ann. 43. 140. (13) J. pr. Chem. 83. 485. Zeitschr Anal. Chem. 6. 217.

<sup>\*</sup> (1) Pogg. Ann. 31. 133. (2) Annalen 188. 264. Zeitschr. Anal. Chem. 5. 351 Phil. Mag. J. [4] 32. 81. Jahresb. 19. 760. (3) Annalen. 83. 257. J. pr. Chem. 58. 187. Ann. Chim. Phys. [3] 88. 104. Jahresb. 5. 292. Gmelin-Kraut. 3. 127. Ros. and Sch. 2. 2. 247. (4) Dingl. Pol. J. 178. 49. Zeitschr. Chem. 1865. 731. Bull. Soc. Chim. [2] 4. 483. Chem. News. 13. 53. Jahresb. 18. 731. (5) Ann. Chim. Phys. 33. 385. Gmelin-Kraut. 3. 128. Ros. and Sch. 2. 2. 247 (6) Chem. Soc. J. 37. 331. (7) Gmelin-Kraut. 3. 128. (8) Compt. rend. 27. 213. Pogg. Ann. 76. 458. Gmelin-Kraut. 3. 128. Miller 562. (9) Ann. Chim. Phys. 33. 385. Pogg. Ann. 9. 434. Gmelin-Kraut 3. 128. Ros. and Sch. 2. 2. 247. (10) Pogg. Ann. 131. 171.

† (1) Chem. Soc. J. 4. 239. Gmelin-Kraut. 3. 124. Jahresb. 4. 350. Ros. and Sch. 2. 2. 242. (2) Gmelin-Kraut. 3. 124. Watts Dict. 5. 806. Ros. and Sch. 2.



mann (3). The anhydrous chloride melts at  $250^{\circ}$  to an oily liquid, Marx (4). Capitaine (5), boils at  $617-628^{\circ}$ , T. Carnelley and W. C. Williams (6), at a heat near redness, J. Davy (7), or a little below, Capitaine (8), always undergoing some decomposition J. Davy (7), the results of which are the perchloride and the yellow earthy subchloride of tin, Capitaine (9). When stannous chloride is heated to bright redness it evolves stannic chlorides, then stannous chloride, and leaves a black glittering residue of metallic tin, A. Vogel (1).\*

*Strontium Chloride.  $SrCl_2$ .*

Strontium chloride with 6 mol. of water melts when heated, loses its water, (2) and becomes anhydrous at  $100^{\circ}$  (3). The anhydrous salt melts at  $825^{\circ}$ , T. Carnelley (4), at  $829^{\circ}$ , T. Carnelley (5), or at  $910^{\circ}$ , Braun (6), to a semi-transparent glassy mass, Dumas (7). When the chloride of strontium is kept for  $\frac{1}{4}$  hour at a temperature at which it begins to volatilize in the form of a white cloud, it yields a mass which dissolves to a strongly alkaline liquid; if this residue be moistened with water and heated again, and this repeated several times, there is formed a brownish-gray strongly alkaline mass, which, on being dissolved, leaves the oxide, Edward Kraus (8). When the salt is melted in the air it becomes alkaline, and at a red heat in a moist atmosphere it evolves hydrochloric acid, Kunheim (9).

*Zinc Chloride.  $ZnCl_2$ .*

Zinc chloride melts at a temperature somewhat above  $100^{\circ}$ , H. Davy (1),† at  $262^{\circ}$  Braun (2), or below a dull red heat, J. Davy (3),

2. 242. (3) Annalen. 83. 274. J. pr. Chem. 58. 189. (4) Gmelin-Kraut 3. 124. Watt's Dict. 5. 806. (5) J. Ph. Chim. Sept. 1839. Phil. Mag. J. [3] 15. 414. (6) Chem. Soc. J. 35. 563. Ber. 12. 1860. (7) Schw. 10. 321. Gmelin-Kraut. 3. 124. Watt's Dict. 5. 806. (8) J. Ph. Chim. Sept. 1839. Phil. Mag. J. [3] 15. 414. Ros. and Sch. 2. 2. 242. (9) J. Ph. Chim. Sept. 1839. Phil. Mag. J. [3] 15. 414. Gmelin-Kraut. 3. 125. Watt's Dict. 5. 806.

\* (1) Schw. 21. 66. Gmelin-Kraut. 3. 124. Watts Dict. 5. 806. (2) Watts Dict. 5. 436. Ros. and Sch. 2. 1. 215. Miller 405. (3) Gmelin-Kraut. 2. 1. 336. (4) Chem. Soc. J. 33. 273. (5) Chem. Soc. J. 29. 489. Zeitschr. Anal. Chem. 17. 469. (6) Pogg. Ann. 154. 190. (7) Ann. Chim. Phys. [3] 55. 191. Gmelin-Kraut. 2. 1. 336. Watts Dict. 5. 436. Ros. and Sch. 2. 1. 215. (8) Pogg. Ann. 43. 139. Bergelius' Jahresb. 19. 234. Gmelin-Kraut. 2. 1. 336. (9) Dissertat Göttingen. 1861. Jahresb. 14. 149. Gmelin-Kraut. 2. 1. 336.

† (1) Gmelin-Kraut. 3. 30. Watts Dict. 5. 1069. Ros. and Sch. 2. 1. 260. Miller 466. (2) Pogg. Ann. 154. 190. (3) Gmelin-Kraut. 3. 30. Watts Dict. 5.

boils at 676–683°, T. Carnelley and W. C. Williams (4), and sublimes at a red heat forming white needle-shaped crystals (5).

### THE IODIDES.

#### *Aluminium Iodide. $Al_2I_6$ .*

Aluminium iodide melts at about 185° to a thin liquid, whose boiling point is higher than that of mercury, Rud. Weber (1);\* melts at 125° and boils at 350°, H. Sainte Claire Deville and Troost (2), or at 360° (3). When heated in a closed tube it sublimes in the form of delicate snow-white laminæ; but in the open air it is rapidly decomposed with the separation of iodine and formation of aluminium oxide, Rud. Weber (4).

#### *Ammonium Iodide. $NH_4I$ .*

Ammonium iodide, when heated, evolves a portion of its ammonia and then sublimes in violet vapors, Gay-Lussac (5). The salt volatilizes without melting or decrepitating, undergoing, however, a partial decomposition, Dr. C. Herzog (6).

#### *Antimonious Iodide. $SbI_3$ .*

Antimonious iodide melts at 171.8 (corr.) and boils at 414–427° with slight decomposition, the vapors having an intense, dark red color. T. Carnelley and W. C. Williams (1).† The salt melts at 167° and boils at a temperature that is higher than the boiling point of mercury, J. P. Cooke (2). Antimonious iodide melts at 164.4°, forming a reddish-brown liquid, which boils at a higher temperature, evolving orange-colored vapors, which condense to transparent bright red plates. When the sublimation is conducted in the air, decomposition takes place, iodine being liberated and oxy-iodide formed, R. W. E. MacIvor (3). The iodide becomes blackish-red every time

1069. (4) Chem. Soc. J. 33. 281. (5) Gmelin-Kraut. 3. 80. Watts Dict. 5. 1069. Ros. and Sch. 2. 1. 260.

\* (1) Pogg. Ann. 103. 259. J. pr. Chem. 74. 165. Chem. Gaz. 16. 269. Phil. Mag. J. [4] 15. 117. Gmelin-Kraut. 2. 1. 641. Watts Dict. 1. 157. Ros. and Sch. 2. 1. 448. (2) Compt. rend. 49. 239. Pogg. Ann. 108. 644. (3) Ros. and Sch. 2. 1. 448. (4) Pogg. Ann. 103. 260. 101. 467. J. pr. Chem. 73. 191. 74. 165. Chem. Centr. 1857. 633. Chem. Gaz. 15. 393. Phil. Mag. J. [4] 15. 117. Amer. J. Pharm. 30. 54. Jahresb. 10. 153. Gmelin-Kraut. 2. 1. 641. (5) Gmelin. Watts Transl. 2. 468. (6) Arch. der Pharm. Oct. 1844. Chem. Gaz. 2. 498.

† (1) Chem. Soc. J. 30. 281. (2) Proc. Amer. Acad. New Series, 6. Ber. 11. 255. Jahresb. Ph. Tox. 1878. 259. (3) Chem. Soc. J. 29. 228. 27. 870. Chem.

it is heated, and at a higher temperature distills in the form of scarlet vapors, Brandes (4). The distillation takes place at a moderate heat, Serrullas (4), a little above its boiling point, Berthelot (4) or even at 100°, J. P. Cook, (5).

*Arsenious Iodide.  $AsI_3$ .*

Arsenious iodide melts at 146°, T. Carnelley (1),\* and boils at 394–414°, T. Carnelley and W. C. Williams (2). When the salt is heated in a retort it becomes fluid and on cooling solidifies again, remaining for the most part undecomposed, a little, however, being converted into iodine and metallic arsenic, Plisson (3); but if the heat be suddenly raised to 138° more complete decomposition takes place, Thomson (4).

*Barium Iodide.  $BaI_2 \cdot 7H_2O$ .*

Barium iodide crystallized with 7 mol. of water melts, when heated, swells up and decrepitates strongly, forming a white mass, which fuses on further application of heat, and on raising the temperature still higher evolves iodine, Henry Croft (5); but when heated out of contact with the air the anhydrous salt is left (6). Barium iodide with 2 mol. of water, when melted in the presence of air, gives off a large amount of iodine, Werther (7). The anhydrous salt is not decomposed by heat in a closed vessel, but in contact with the air it rapidly decomposes, giving off vapors of iodine and leaving baryta behind (1).† Barium iodide after being melted crystallizes on cooling, J. Dumas (2).

*Bismuth Iodide.  $BiI_3$ .*

Bismuth iodide, when heated in a closed vessel, may be partially volatilized without alteration (3); but when heated in the air, it gives off brown vapors and leaves behind a basic iodide, R. Schneider (4), or is entirely converted into the oxide (3). When the salt is

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News 29. 255. (4) Gmelin, Watts Transl. 4. 362. (5) Proceed. Amer. Acad. New Series, 5. Jahresb. 30. 284. Jahresb. Ph. Tox. 1878. 259.

\* (1) Chem. Soc. J. 33. 270. (2) Chem. Soc. J. 33. 281. (3) Ann. Chim. Phys. 39. 265. Pogg. Ann. 14. 609. Gmelin, Watts Transl. 4. 281. (4) Gmelin, Watts Transl. 4. 281. (5) Chem. Gaz. 15. 126. Ber. 10. 1343. J. pr. Chem. 68. 402. Chem. Centr. 1856. 404. Jahresb. 9. 333. (6) Watts Dict. 1. 504. (7) J. pr. Chem. 91. 331. Jahresb. 17. 189. Gmelin-Kraut. 2. 1. 293.

† (1) Watts Dict. 1. 504. (2) Ann. Chim. Phys. [3] 55. 191. (3) Watts Dict. 1. 594. (4) Pogg. Ann. 99. 470. Annalen 101. 66. J. pr. Chem. 70. 119. Ann.

heated in an open glass tube, it does not melt, but decomposes partially under the separation of iodine and formation of orange-red oxy-iodide of bismuth, J. Nickels (5).

*Cadmium Iodide.  $CdI_2$ .*

Cadmium iodide melts at  $402^\circ$ , W. E. Kay (6), at  $404^\circ$ , T. Carnelley (7), and solidifies again in a crystalline form; but when exposed to a more elevated temperature it decomposes under the loss of iodine, Stromeyer (8).

*Calcium Iodide.  $CaI_2$ .*

Calcium Iodide melts at  $631^\circ$ , T. Carnelley (1),\* or below a red heat (2), crystallizing on cooling, J. Dumas (3), and, when heated in contact with the air, is decomposed with the formation of lime, and separation of iodine, Gay-Lussac (4).

*Cobaltous Iodide.  $CoI_2 \cdot 6H_2O$ .*

Cobaltous iodide with 6 mol. of water becomes anhydrous at  $130^\circ$ , Walter Noel Hartley (5). The salt with 2 mol. of water ( $CoI_2 \cdot 2H_2O$ ), when heated at  $100^\circ$ , gives off a portion of its iodine under the formation of cobaltous oxide, W. N. Hartley (6).

*Cuprous Iodide.  $Cu_2I_2$ .*

Cuprous iodide melts at  $601^\circ$ , T. Carnelley (1), or at a red heat, forming a brown mass, on cooling, whose powder is green, Soubeiran (7).

*Ferrous Iodide.  $FeI_2$ .*

Ferrous iodide, crystallized with 5 mol. of water, when heated at over  $100^\circ$  in the air, evolves water and iodine and leaves ferric oxide behind, J. D. Smith (8), or a residue that is attracted by the

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Chim. Phys. [3] 50. 488. Chem. Centr. 1857. 57. Chem. Gaz. 15. 109. Jahresb. 9. 392. (5) Compt. rend. 50. 872. Instit. 1860. 156. J. Ph. Chim. [3] 37. 436. Jahresb. 13. 176. (6) Annalen 207. 65. (7) Chem. Soc. J. 33. 273. (8) Ann. Chim. Phys. 11. 83. Watts Dict. 1. 705. Ros. and Sch. 2. 1. 268.

\* (1) Chem. Soc. J. 33. 273. (2) Watts' Dict. 1. 718. (3) Ann. Chim. Phys. [3] 55. 191. (4) Gilb. Ann. 49. 237. Gmelin-Kraut 2. 1. 391. Watts Dict. 1. 718. (5) Chem. News. 29. 161. Ros. and Sch. 2. 2. 131. (6) Chem. News. 29. 161. Chem. Soc. J. 27. 501. Jahresb. 27. 273. (7) Gmelin-Kraut 3. 635. Watts Dict. 2. 66. Ros. and Sch. 2. 1. 333. (8) Phil. Mag. J. 7. 156. Gmelin-Kraut 3. 350.

magnet, Faville (1). The anhydrous salt melts at  $177^{\circ}$ , Carius and Wanklyn (2), or at a red heat, forming on cooling a gray laminar mass and volatilizing at a stronger heat (3); but when heated in the air, violet vapors of iodine are evolved and a magnetic residue left behind, Faville (4), or ferric oxide alone remains, Todd. Thomson (5).

*Lead Iodide.  $PbI_2$ .*

Lead iodide, when heated, becomes reddish yellow, then a bright red and finally assumes a brownish black color, O. Henry (6), Brandes (7), and melts at a higher temperature, Gay-Lussac (8), or at  $383^{\circ}$ , T. Carnelley (9), to a reddish-brown liquid, which on cooling solidifies to a yellow mass, Brandes (10). If the salt be melted in the air, iodine is evolved and oxy-iodide of lead formed, Brandes (11).

*Magnesium Iodide.  $MgI_2$ .*

Magnesium iodide, when moistened and heated, gives off hydriodic acid, and leaves pure magnesia (1).\*

*Manganous Iodide.  $MnI_2$ .*

Manganous iodide may be fused without decomposition when the air is excluded; but on admission of the air it is resolved into vapor of iodine and manganous oxide, Lassaigue (2).

*Mercuric Iodide.  $HgI_2$ .*

Mercuric iodide turns yellow when gently heated, melts at a higher temperature (3), at  $200^{\circ}$ , G. F. Rodwell and H. M. Elder (4), at  $238^{\circ}$ , Oppenheim (5), or at  $253-254^{\circ}$ , H. Köhler (6), boils at

(1) Compt. Rend. 55. 615. J. pr. Chem. 89. 253. Jahresb. 15. 192. (2) Annalen 120. 69. Gmelin-Kraut 3. 350. Ros. and Sch. 2. 2. 93. (3) Watts Dict. 3. 390. (4) Compt. rend. 55. 615. J. pr. Chem. 89. 253. (5) Gmelin-Kraut 3. 350. (6) Gmelin-Kraut 3. 242. Watts Dict. 3. 547. Ros. and Sch. 2. 1. 287. (7) Annalen 10. 266. Gmelin-Kraut 3. 242. (8) Gmelin-Kraut 3. 242. (9) Chem. Soc. J. 33. 273. (10) Annalen 10. 266. Gmelin-Kraut 3. 242. Watts Dict. 3. 547. Ros. and Sch. 2. 1. 287. (11) Annalen 10. 266. Gmelin-Kraut 3. 242. Watts Dict. 3. 547.

\* (1) Gmelin-Kraut 2. 1. 464. Watts Dict. 3. 754. Ros. and Sch. 2. 1. 242. (2) Gmelin-Kraut 2. 2. 492. Watts Dict. 3. 808. Ros. and Sch. 2. 2. 8. (3) Watts Dict. 3. 904. Ros. and Sch. 2. 1. 406. (4) Proc. Roy. Soc. 28. 284. Miller 660. (5) Clarke's Constants of Nature. Gmelin-Kraut 3. 772. (6) Ber. 12. 608. Chem. Soc. J. 36. 602. Chem. News. 40. 77. Amer.

339–359°, T. Carnelley and W. C. Williams (7), and sublimes in bright yellow rhombic prisms (8). When mercuric iodide is put into a retort and heated, it melts and then volatilizes as a colorless gas, which condenses to a brown fluid, Deville (9). For the change of color that the salt undergoes in passing from one modification to the other by the aid of heat, see M. A. Hays (1),\* R. Warington (2), Mitscherlich (3), G. F. Rodwell and H. M. Elder (4), and H. F. Talbot (5). If goldleaf be brought in contact with the vapors of mercuric iodide, heated to a red heat, it will become white and brittle under the formation of an amalgam, Debray (6).

*Mercurous Iodide.  $Hg_2I_2$ .*

Mercurous iodide, when heated, yields a sublimate of metallic mercury, and mercurous-mercuric iodide, Labouré (7), or simply mercuric iodide (8). If the salt be carefully heated, it sublimes unchanged; but if rapidly heated, it melts at 290° to a black liquid, which boils at 310°, mercury being given off, and an oxy-iodide sublimed, P. Yvon (9).

*Nickelous Iodide.  $NiI_2 \cdot H_2O$ .*

Nickelous iodide with 6 mol. of water, when heated in contact with the air, gives off a little iodine, yields a sublimate of the anhydrous salt and leaves a residue of oxide of nickel (1).† The anhydrous salt, when heated out of contact with the air, sublimes without melting, only a trace of iodine vapor appearing; but if the sublimation be carried on in the open air much iodine is evolved and a residue of nickelous oxide with an unweighable trace of iodine is left behind, Erdmann (2).

J. Pharm. 51. 852. Jahresb. Ph. Tox. 1879. 123. (7) Chem. Soc. J. 33. 282. (8) Watts Dict. 3. 904. Ros. and Sch. 2. 1. 406. (9) Compt. rend. 62. 1157. Annalen 140. 170. J. pr. Chem. 99. [8]. Jahresb. 19. 41. Gmelin-Kraut 3. 773.

\* (1) Schw. 59. 199. Amer. J. Sci. 16. 174. Phil. Mag. J. [3] 22. 210. (2) Phil. Mag. J. 21. 192. (3) Pogg. Ann. 28. 116. (4) Proc. Roy. Soc. 28. 284. Chem. Soc. J. 38. 443. (5) Phil. Mag. J. [3] 9. 1. (6) Compt. rend. 66. 1339. Instit. 1868. 210. Zeitschr. Chem. 1868. 543. J. pr. Chem. 107. 254. Amer. J. Sci. [2] 46. 398. (7) J. Ph. Chim. [3] 4. 329. Gmelin-Kraut 3. 770. Watts Dict. 3. 904. (8) Watts Dict. 3. 904. Miller 660. (9) J. Ph. Chim. [4] 18. 167. Chem. Soc. J. 26. 1105. Chem. News 28. 44. Amer. Chem. 4. 356. Amer. J. Pharm. 45. 475. 525. Jahresb. Ph. Tox. 1873. 295. Ros. and Sch. 2. 1. 401.

† (1) Watts Dict. 4. 40. (2) J. pr. Chem. 7. 256. Gmelin-Kraut 3. 551

*Potassium Iodide. KI.*

Potassium iodide melts at 634°, T. Carnelley (3), at 666°, Braun (4), or at 668°, T. Carnelley (5), solidifying again at 622°, T. Carnelley (6), to a pearly crystalline mass, Gay-Lussac (7), and when exposed to the air volatilizes undecomposed at a moderate heat (8). When the salt is dried at 180–200°, it undergoes no change; but if heated for ½ hour at 230–250°, it will be found to contain some iodic acid, Otto Petterson (9). For comparison of the volatility of potassium iodide with that of sodium chloride, see Bunsen (10).

*Silver Iodide. AgI.*

Silver iodide, when heated, remains unchanged in color up to about 105°; between 105° and 180° it assumes darker and darker shades of yellow; above 180° it becomes decidedly red, and darkens as the temperature is raised to 412°, at which point it is brick-red. At about 450° it fuses to a dark red liquid and begins to volatilize and decompose at a red heat. When cooled from 450° to 116° it contracts; but below 116° to –18° it expands, G. F. Rodwell (1).<sup>\*</sup> Silver iodide fuses at 400° and on cooling expands between –10° and +70°, Fizeau (2).

When the fused salt is cooled to 138°, it exhibits a sudden alteration of color and transparency, Wernicke (3). Silver iodide melts at 527°, T. Carnelley (4), at 530°, T. Carnelley (5), or at a dull red heat (6), to a red liquid, which on cooling solidifies to a dingy yellow mass (7), of a horny texture, Berzelius (6), Stas (6), clear as

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(3) Chem. Soc. J. 33. 273. (4) Pogg. Ann. 154. 190. (5) Chem. Soc. J. 31. 381. Zeitschr. Anal. Chem. 19. 175. (6) Chem. Soc. J. 29. 499. (7) Gilb. Ann. 49. 26. Gmelin-Kraut 2. 1. 58. (8) Gmelin-Kraut 2. 1. 58. Watts Dict. 4. 704. (9) Zeitschr. Anal. Chem. 9. 362. Jahresb. Ph. Tox. 1870. 285. (10) Annalen 138. 264. Zeitschr. Anal. Chem. 5. 351. Phil. Mag. J. [4] 32. 81. Jahresb. 19. 766.

<sup>\*</sup> (1) Proc. Roy. Soc. 23. 97. Chem. News 30. 289. See also Proc. Roy. Soc. 25. 280. Amer. Chem. 5. 430. Zeitschr. Anal. Chem. 14. 190. Ber. 7. 1794. (2) Compt. rend. 64. 314. 771. Pogg. Ann. 132. 292. Instit. 1867. 130. J. Ph. Chim. [4] 6. 435. Bull. Soc. Chim. [2] 8. 161. J. pr. Ch. 100. 507. Zeitschr. Chem. 1867. 171. Chem. News 15. 215. 16. 37. Phil. Mag. J. [4] 35. 456. Jahresb. 20. 44. Gmelin-Kraut 3. 930. Proc. Roy. Soc. 23. 97. Ros. and Sch. 2. 1. 374. (3) Pogg. Ann. 143. 560. Proc. Roy. Soc. 25. 280. (4) Chem. Soc. J. 33. 273. (5) Chem. Soc. J. 29. 489. Zeitschr. Anal. Chem. 17. 469. (6) Gmelin-Kraut 3. 930. (7) Watts Dict. 5. 301.

glass, Schultz-Sellack (1). For an experiment with a paper coated with iodide of silver and held before the fire, see Talbot (2), and for the same experiment on porcelain, see Erdmann (3).

*Sodium Iodide. NaI.*

Anhydrous sodium iodide melts at 628°, T. Carnelley (4), or at 633°, T. Carnelley (5), forming on cooling a radiant pearly mass, Girault (6), and at a higher temperature volatilizing with a loss of part of its iodine (7). Sodium iodide, when melted in the air, loses some iodine under the formation of the oxide, Berzelius (6), and is less easily vaporized than potassium iodide, Gay-Lussac (6), Girault (6); but is more volatile than sodium chloride, Mohr (8); for comparison with the volatility of which, see Bunsen (9).

*Stannic Iodide. SnI<sub>4</sub>.*

Stannic iodide melts at 146°, J. Personne (1),\* solidifies again at 142°, J. Personne (2), sublimes at 180°, Thomas H. Henery (3), boils at 295°, J. Personne (4), or at 300° (5), and the vapors condense to yellowish-red needles very similiar in form to those of sal-ammoniac, J. Personne (6).

*Stannous Iodide. SnI<sub>2</sub>.*

Stannous iodide melts at a dark red heat and distills at the temperature of melting glass, J. Personne (7); melts at 316°, and decomposes rapidly on boiling, T. Carnelley and W. C. Williams, (8). The salt can be heated to redness if protected from the

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(1) Gmelin-Kraut 3. 930. (2) Phil. Mag. J. [3] 12. 258. Pogg. Ann. 46. 326. J. pr. Chem. 4. 123. Gmelin-Kraut 3. 930. (3) J. pr. Chem. 14. 123. Gmelin-Kraut 3. 930. (4) Chem. Soc. J. 33. 273. (5) Chem. Soc. J. 29. 489. Zeitschr. Anal. Chem. 17. 469. (6) Gmelin-Kraut 2. 1. 195. (7) Watts Dict. 5. 338. (8) Annalen 21. 66. Gmelin-Kraut 2. 1. 195. (9) Annalen 138. 264. Zeitsch. Anal. Chem. 5. 351. Phil. Mag. [4] 32. 84. Jahresb. 19. 766.

\* (1) Compt. rend. 54. 216. J. pr. Chem. 88. 76. Jahresb. 15. 171. Gmelin-Kraut 3. 122. Watts Dict. 5. 814. Ros. and Sch. 2. 2. 249. (2) Compt. rend. 54. 216. J. pr. Chem. 88. 76. Gmelin-Kraut 3. 122. Watts Dict. 5. 814. (3) Phil. Trans. 1845. 863. Abst. to Phil. Trans. of Roy. Soc. 5. 565. Chem. Gaz. 3. 397. Annalen 60. 215. Gmelin-Kraut 3. 122. Watts Dict. 5. 814. Ros. and Sch. 2. 2. 248. (4) Compt. rend. 54. 3. 216. J. pr. Chem. 88. 76. Jahresb. 15. 171. Gmelin-Kraut. 3. 122. Watts Dict. 5. 814. (5) Ros. and Sch. 2. 2. 249. (6) Compt. rend. 54. 216. J. pr. Chem. 88. 76. Jahresb. 15. 171. Gmelin-Kraut 3. 122. Ros. and Sch. 2. 2. 249. (7) Compt. rend. 54. 216. J. pr. Chem. 88. 76. Chem. Centr. 1862. 785. Zeitsch. Chem. Pharm. 1862. 174. Rep. Chim. pure. 4. 129. Jahresb. 15. 171. Gmelin-Kraut. 3. 121. Watts Dict. 5. 814. Ros. and Sch. 2. 2. 248. (8) Chem. Soc. J. 35. 563.



air without subliming, Thomas H. Henry (9); but when heated in the air it decomposes; stannic iodide subliming and stannous oxide remaining (1);\* or yields besides stannic oxide, a substance which with water decomposes into stannic oxide and hydriodic acid, Boullay, (2), or into stannic oxide and stannic iodide, T. H. Henery (3).

*Strontium Iodide.*  $Sr_3.6H_2O$ .

Strontium iodide crystallizes with 6 mol. of water, melts when heated, swells up and decrepitates strongly, forming a white mass which fuses on further application of heat, and on raising the temperature still higher evolves iodine, Henry Croft (4). The anhydrous salt melts at  $507^\circ$ , T. Carnelley (5), solidifying to a glassy mass, Dumas (6), and undergoing no decomposition in a closed vessel; but when heated in contact with the air, it gives off iodine and is converted into strontia, Gay-Lussac (7).

*Zinc Iodide.*  $ZnI_2$ .

Zinc iodide melts at  $446^\circ$ , T. Carnelley (5), and decomposes when heated in the air into vapor of iodine and zinc oxide, Gay-Lussac (8).

## THE NITRATES.

*Aluminium Nitrate.*  $Al(NO_3)_3.18H_2O$ .

Aluminium nitrate crystallized with 18 mol. of water, melts at  $72.8^\circ$ , boils at  $134^\circ$ , J. M. Ordway (1),† and decomposes at  $150^\circ$  (2); at  $140^\circ$  all the acid is expelled, H. Sainte-Claire Deville (3), and, at  $200$ – $250^\circ$  aluminium oxide remains, Schlösing (4), but by partial decomposition a basic salt is formed, Ordway (5).

*Ammonium Nitrate.*  $NH_4NO_3$ .

Ammonium nitrate fuses imperfectly at  $56^\circ$  (6), perfectly at  $108^\circ$

(9) Phil. Trans. 1845, 363. Annalen 60. 215. Chem. Gaz. 3. 397. Abst. to Phil. Trans. Roy Soc. 5. 565.

\* (1) Watts Dict. 5. 814. (2) Ann. Chem. Phys. 34. 372. Gmelin-Kraut. 8. 121. (3) Phil. Trans. 1845, 363. Gmelin-Kraut 8. 121. (4) Chem. Gaz. 15. 126. J. pr. Chem. 68. 402. Ber. 10. 1848. Chem. Centr. 1856, 404. Jahresh. 9. 333. (5) Chem. Soc. J. 33. 273. (6) Ann. Chim. Phys. [3] 55. 191. Gmelin-Kraut. 2. 1. 332. (7) Gmelin-Kraut. 2.1. 332. Watts Dict. 5. 437. (8) Gmelin-Kraut. 3. 28. Watts Dict. 5. 1072.

† (1) Amer. J. Sci. [2] 37. 111. Ann. Chim. Phys. 76. 248. Chem. Gaz. 8. 61. Watts Dict. 4. 89. (2) Ros. and Sch. 2. 1. 457. (3) Ann. Chim. Phys. [3] 38. 9. Gmelin-Kraut 2. 1. 650. (4) Grandea. Traite d'analyse. Paris. 1877, 105. (5) Amer. J. Pharm. [2] 26. 203. Gmelin-Kraut 2. 1. 650. (6) Gmelin. Watts

(7), at 145°, Frankenheim (8), at 152°, Berthelot (9), or at 165°–166°, S. Pickering (10), boils at 180° without decomposition (11), and begins to decompose at 185° into nitrous oxide and water, S. Pickering (10), at 210°, the gas increasing as the temperature is raised, Berthelot (9), at 238° (12), or at 230–250° (13), while at 250° the gas is evolved in abundance (12).

The decomposition does not take place below 190°–200°, Le-grand (1),\* and if the temperature be raised above 300° the reaction becomes explosive, Berthelot (2). If the salt be rapidly heated, ammonia, nitric oxide and nitrite of ammonium are formed, in addition to nitrous oxide, Berzelius (3). When the salt is placed upon a red-hot plate a yellow flame is produced, and a slight explosion occurs, accompanied by decomposition into nitrogen, water, and nitric oxide, a small portion of the salt subliming unchanged (4). For the construction of an apparatus for subliming the salt without decomposition, see Berthelot (5). For a tabulated statement of the reaction at different degrees, see (6). For the composition of the gas after it has been passed through water, and the theory of its formation, see P. A. Favre and J. I. Silbermann (7).

### *Barium Nitrate. Ba(NO<sub>3</sub>)<sub>2</sub>.*

Barium Nitrate melts at 593°, T. Carnelley (8), and decomposes at a red heat, giving off oxygen, nitrogen, and peroxide of nitrogen (9), or nitrous anhydride, Riviere (10), and leaving a residue of pure baryta (1) † or of Ba<sub>2</sub>O<sub>3</sub>, Rammelsberg (2). Barium nitrate is entirely decomposed in a retort at a heat a little above that of simple

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Trans. 2. 490. (7) Gmelin. Watts Trans. 2. 490. Watts Dict. 1. 192. Miller 393. (8) Pogg. Ann. 93. 17. (9) Compt. rend. 82. 388. Ann. Chim. Phys. [5] 10. 362. J. Ph. Chem. [5] 24. 352. Chem. Soc. J. 32. 840. Jahresb. Ph. Tox. 1876, 288. Jahresb. 29. 193. (10) Chem. News. 38. 267. Chem. Soc. J. 36. 200. Jahresb. 31. 221. (11) Watts Dict. 1. 192. Amer. J. Pharm. 40. 409. (12) Gmelin. Watts Trans. 2. 490. Amer. J. Pharm. 40. 409. (13) Watts Dict. 1. 192.

\* (1) Ann. Chim. Phys. 59. 435. (2) Ann. Chim. Phys. [5] 10. 362. J. ph. Chim. [5] 24. 352. Chem. Soc. J. 32. 840. (3) Watts Dict. 1. 192. (4) Ros. and Sch. 2. 1. 180. (5) Compt. rend. 82. 388. Chem. News 33. 210. Ber. 9. 730. (6) Amer. J. Pharm. 40. 409. (7) Ann. Chim. Phys. [3] 36. 19. (8) Chem. Soc. J. 33. 275. Ros. and Sch. 2. 1. 226. (9) Gmelin-Kraut 2. 1. 307. Watts Dict. 4. 89. (10) Mulhous. Soc. Bull. 36. 438. Gmelin-Kraut 2. 1. 307.

† (1) Gmelin-Kraut 2. 1. 307. Watts Dict. 4. 89. Miller 403. (2) Pogg. Ann. 187. 315. J. pr. Chem. 107. 353. Bull. Soc. Chim. [2] 12. 349. Zeitschr. Chem.

redness, H. Diville and H. Debray (3). Barium nitrite can be formed from the nitrate by a gentle and not too continuous red heat, Hess (4), by ignition, N. W. Fischer (5), or by keeping the salt at its melting point, Hampe (6).

*Bismuth Nitrate*  $\text{Bi}(\text{NO}_3)_3 \cdot 10\text{H}_2\text{O}$ .

Bismuth nitrate when gently heated melts in its water of crystallization (7); at  $78^\circ$  it becomes a basic salt ( $\text{Bi}_2\text{O}_3 \cdot \text{N}_2\text{O}_5 \cdot \text{H}_2\text{O}$ ), Graham (8), Ruge (9), the same being formed at  $150^\circ$ , Gladstone (10), which at  $160^\circ$  degrees sustains scarcely any further loss, Graham (11), or, on the other hand, it does give up its acid and water at that temperature, Gladstone (12).

*Cadmium Nitrate*  $\text{Cd}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$ .

Cadmium nitrate melts at  $59.5^\circ$ , Ordway (1),\* or at  $100^\circ$ , Carl von Hauer (2), and boils at  $132^\circ$ , remaining clear and mobile on prolonged boiling until  $\frac{2}{3}$  of the water has been expelled, Ordway (3).

*Calcium Nitrate.*  $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$ .

Calcium nitrate crystallized with 4 mol. of water melts at  $44^\circ$ , Ordway (3), forming a mobile liquid, Million (4), which boils at  $132^\circ$ , remaining clear until about  $\frac{1}{3}$  of the water has been driven off, and then depositing the anhydrous salt, Ordway (3). Anhydrous calcium nitrate melts at  $561^\circ$ , T. Carnelley (5), remaining undecomposed at an incipient fusion, but at a higher temperature decomposing with the evolution of oxygen and peroxide of nitrogen (6). Some nitrite of calcium is formed by ignition, N. W. Fischer (7), a little being formed even before the entire mass is

1869. 373. Jahresb. 22. 223. Gmelin-Kraut 2. 1. 307. 258. (3) Ann. Chim. Phys. [3] 61. 118. (4) Pogg. Ann. 12. 270. Gmelin-Kraut 2. 1. 306. (5) Pogg. Ann. 74. 116. Chem. Gaz. 6. 281. (6) Annalen 125. 337. Jahresb. 16. 160. (7) Watts Dict. 4. 90. (8) Annalen 29. 16. Gmelin, Watts Transl. 4. 443. (9) Jahresb. 15. 163. (10) Mem. and Proc. Chem. Soc. 3. 480. J. pr. Chem. 44. 179. Jahresb. 1. 432. Watts Dict. 4. 90. (11) Gmelin, Watts Transl. 4. 443. (12) Mem. and Proc. Chem. Soc. 3. 480. J. pr. Chem. 44. 179. Jahresb. 1. 432. Gmelin, Watts Transl. 4. 443.

\* (1) Amer. J. Sci. [2] 27. 14. Gmelin-Kraut 3. 73. Watts Dict. 4. 90. (2) Wien. Akad. Ber. 15. 23. J. pr. Chem. 64. 477. Chem. Soc. J. 8. 251. Chem. Gaz. 13. 221. Jahresb. 8. 391. Gmelin-Kraut 3. 73. (3) Amer. J. Sci. [2] 27. 14. Jahresb. 12. 115. Gmelin-Kraut 3. 73. Watts Dict. 4. 90. (4) Compt. rend. 4. 905. Gmelin-Kraut 2. 1. 410. (5) Chem. Soc. J. 33. 275. (6) Gmelin-Kraut 2. 1. 410. Watts Dict. 4. 90. (7) Pogg. Ann. 74. 115. An-

melted, J. Lang (1).<sup>\*</sup> When the salt is heated just to the beginning of decomposition a phosphorescent residue remains (2).

*Chromium Nitrate.*  $\text{Cr}_2(\text{NO}_3)_4 \cdot 18\text{H}_2\text{O}$ .

Chromium nitrate melts at  $37^\circ$  to a green liquid, which boils at  $125.5^\circ$ , Ordway (3). When the salt is heated on the water-bath until 39 per cent. of its weight is lost, the residue consists of  $\text{Cr}_2\text{O}_3 \cdot 2\text{N}_2\text{O}_5 \cdot 12\text{H}_2\text{O}$ ; on continuing the heat, the residue, when dissolved in water, consists of chromate and nitrate of chromium, Ordway (4); the formation of chromic acid increases as the temperature is raised to redness, at which point nitric acid and oxygen are evolved and the green oxide left behind, Elliot and Storer (5).

Complete decomposition takes place at a red heat, with the formation of the oxide, Maus (6), Ordway (7).

*Cobaltous Nitrate.*  $\text{Co}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ .

Cobaltous nitrate melts below  $100^\circ$ ; when heated more strongly the violet liquid becomes thick and green, and then begins to boil, giving off nitrous fumes and leaving the black cobaltoso-cobaltic oxide behind (1).<sup>†</sup>

*Cupric Nitrate.*  $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$ .

Cupric nitrate crystallized with 3 mol. of water melts at  $114.5^\circ$  and boils at  $170^\circ$ , giving off nitric acid and leaving a green basic salt, Ordway (2); at  $65^\circ$  it begins to lose nitric acid, a basic salt having the composition  $\text{Cu}(\text{NO}_3)_2 + 3\text{Cu}(\text{OH})_2$  being formed, Gra-

halen 68. 224. J. pr. Chem. 46. 318. Pharm. Centr. 1848. 401. Jahresb. 1. 333. Chem. Gaz. 6. 281.

<sup>\*</sup>(1) Pogg. Ann. 118. 282. J. pr. Chem. 86. 395. J. Ph. Chim. [3] 42. 341. Rep. Ch. pure. 5. 77. Jahresb. 15. 101. Gmelin-Kraut 2. 1. 409. (2) Gmelin-Kraut 2. 1. 409. (3) Amer. J. Sci. [3] 27. 14. 9. 30. Annalen 76. 248. Jahresb. 12. 114. Gmelin-Kraut 2. 2. 326. Watts Dict. 4. 91. (4) Amer. J. Sci. [2] 26. 197. Jahresb. 11. 113. Gmelin-Kraut 2. 2. 326. Watts Dict. 4. 91. (5) Proc. Amer. Acad. 5. 192. Arch. Pharm. [2] 110. 221. Rep. Ch. appli. 3. 390. Jahresb. 14. 251. Gmelin-Kraut 2. 2. 291. (6) Pogg. Ann. 9. 127. Gmelin-Kraut 2. 2. 291. (7) Amer. J. Sci. [2] 9. 30. Chem. Gaz. 8. 61. Gmelin-Kraut 2. 2. 326.

<sup>†</sup>(1) Gmelin-Kraut 3. 458. Watts Dict. 4. 91. Ros. and Sch. 2. 1. 131. (2) Amer. J. Sci. [2] 27. 15. Jahresb. 12. 114. Gmelin-Kraut 3. 651. Watts Dict.

ham (3), Gerhardt (4), which is not decomposed at the temperature of melting lead; but at a stronger heat it evolves nitric acid, peroxide of nitrogen, oxygen, and water, and leaves cupric oxide (5). The salt with 6 mol. of water melts at  $38^{\circ}$ , is then, under loss of water and acid, transformed into a basic salt, and finally leaves 27 per cent. of the oxide, Proust (6).

*Ferric Nitrate.*  $Fe_2(NO_3)_4 \cdot 18H_2O$ .

Ferric nitrate with 18 mol. of water melts at  $47.2^{\circ}$  to a clear deep-red liquid, which remains fluid until cooled to  $28.3^{\circ}$ , and which boils at  $125^{\circ}$ , decomposing partially at  $100^{\circ}$ , entirely at a red heat, Ordway (1),\* even losing some of its acid at  $50^{\circ}$ , Scheurer-Kestner (2), ferric oxide being formed, H. Sainte-Clare Deville (3).

The nitrate with 12 mol. of water ( $Fe_2(NO_3)_4 \cdot 12H_2O$ ) melts at  $35^{\circ}$ , S. Hausmann (4), between  $35^{\circ}$  and  $40^{\circ}$ , Ordway (5), or under  $50^{\circ}$ , Schönbein (6).

*Lead Nitrate.*  $Pb(NO_3)_2$ .

Lead nitrate decrepitates when heated, detonates when thrown upon red-hot charcoal (7), and decomposes at an incipient red heat, yielding a mixture of oxygen and nitric peroxide, and leaving the yellow protoxide of lead.  $Pb(NO_3)_2 = PbO + O + 2NO_2$  (8). For the formation of nitrite of lead by the action of heat upon the nitrate, see Bley (9).

*Magnesium Nitrate.*  $Mg(NO_3)_2 \cdot 6H_2O$ .

Crystallized magnesium nitrate melts at  $90^{\circ}$ , begins to boil at  $143^{\circ}$ , and remains on further boiling a clear liquid, until 5 mol. of

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4. 92. (3) Phil. Trans. 1837. 57. Watts Dict. 4. 92. Ros. and Sch. 2. 1. 340. (4) Watts Dict. 4. 92. (5) Gmelin-Kraut 3. 650. Watts Dict. 4. 92. Ros. and Sch. 2. 1. 340. (6) Gmelin-Kraut 3. 651. Miller 623.

\* (1) Amer. J. Sci. [2] 27. 14. Jahresb. 3. 327. 12. 114. Chem. Gaz. 8. 61. Gmelin-Kraut 3. 369. Watts Dict. 4. 93. (2) Gmelin-Kraut 3. 369. (3) Ann. Chim. Phys. (3) 38. 8. (4) Annalen 89. 109. J. pr. Chem. 61. 185. Pharm. Centr. 1854. 298. Chem. Gaz. 12. 211. Amer. J. Pharm. 26. 316. Jahresb. 6. 371. Gmelin-Kraut 3. 369. (5) Gmelin-Kraut 3. 369. (6) Pogg. Ann. 39. 141. Gmelin-Kraut 3. 369. (7) Gmelin-Kraut 3. 261. Ros. and Sch. 2. 1. 289. Miller 640. (8) Gmelin-Kraut 3. 261. Watts Dict. 4. 94. Miller 640. (9) J. pr. Chem. 39. 28. Gmelin-Kraut 3. 255.

water and some acid have been expelled, Ordway (1).\* By melting, the salt loses 34.14 per cent. of its water; the fused residue is not entirely deprived of its water at 400°, but loses the whole at a dark-red heat, together with a portion of its acid, which is volatilized as peroxide of nitrogen and oxygen, Graham (2). The nitrate of magnesium loses 5 mol. of water at 210°, and at 250°-255° the 6 mol., together with some nitric acid, Chodnew (3).

*Manganous Nitrate.*  $Mn(NO_3)_2 \cdot 6H_2O$ .

Manganous nitrate with 6 mol. of water, when heated, melts easily, John (4), even below 50-60°, Lührs (4), or at 25.8°, and boils at 129.5°, and if the boiling be continued there soon separates out the peroxide of manganese, Ordway (5).

Di-oxide of manganese is formed when the nitrate is heated at 150-195°, Schlösing (1),† or at 200, Kuhlmann (2.)

*Mercuric Nitrate.*  $Hg(NO_3)_2 \cdot 8H_2O$ .

Mercuric nitrate melts at 6.6, forming a solution from which crystals of the composition  $HgO \cdot Hg(NO_3)_2 \cdot 3H_2O$  are deposited, Dritten (3). By heating either of the above salts until a pulverulent mass is obtained, pulverizing and treating 7 or 8 times with water, then the tri-mercuric salt is obtained,  $Hg_3(NO_3)_8 \cdot H_2O$ , which gives off its water at about 120°, and nitrous fumes at 250°, Million (4).

*Mercurous Nitrate.*  $Hg_2(NO_3)_2$ .

Mercurous nitrate melts at 100°, and if the heat be maintained it liberates water and nitric acid, nitrous vapors and deutoxide of nitrogen, leaving a yellow crystalline salt, which is the sub-nitrate of the proto-peroxide of mercury, C. Gerhardt (5). Mercurous nitrate, when heated, decomposes into hyponitric acid and mercuric oxide,  $Hg_2(NO_3)_2 = 2HgO + N_2O_4$  (6).

\* (1) Amer. J. Sci. [2] 27. 14. Jahresb. 12. 113. (2) Schw. 55. 195. Gmelin-Kraut 2. 1. 474. Watts Dict. 4. 95. (3) Annalen 71. 241. J. pr. Chem. 49. 107. Pharm. Centr. 1849. 857. Jahresb. 2. 262. Gmelin-Kraut 2. 1. 474. Watts Dict. 4. 95. (4) Gmelin-Kraut 2. 2. 501. (5) Amer. J. Sci. [2] 27. 14. Jahresb. 12. 114. Gmelin-Kraut 2. 2. 501. Ros. and Sch. 2. 2. 9.

† (1) Compt. rend. 55. 284. Instit. 1862. 261. Rep. Chim. pure. 4. 378. Zeitschr. Chem. Pharm. 1862. 571. Chem. Centr. 1863. 7. Dingl. Polyt. J. 166. 197. Jahresb. 15. 659. Gmelin-Kraut 2. 2. 446. (2) Dingl. Polyt. J. 211. 25. Jahresb. 27. 271. Gmelin-Kraut 2. 2. 446. (3) Jahresb. 7. 366. Gmelin-Kraut 3. 812. Watts Dict. 4. 96. (4) Am. Chim. Phys. [3] 18. 361. Gmelin-Kraut 3. 810. Watts Dict. 4. 96. (5) Compt. rend. 1848. 432. Chem. Gaz. 6. 249. (6) Gmelin-Kraut 3. 809.

*Nickelous Nitrate.  $Ni(NO_3)_2 \cdot 6H_2O$ .*

Nickelous nitrate with 6 mol. of water melts at  $56.7^\circ$ , and boils at  $136.7^\circ$ ; on continuation of boiling the liquid remains clear until 3 mol. of water are driven off, and then becomes thick under loss of acid, Ordway, (1).\*

When nickelous nitrate is heated it leaves a yellow-green pulverulent basic salt, then peroxide and finally protoxide of nickel (2).

*Potassium Nitrate.  $KNO_3$ .*

Potassium nitrate melts at  $313^\circ$  (3), at  $339^\circ$ , C., Person (4), Quincke (5), T. Carnelley (6), at  $342^\circ$ , Braun (7), or at  $368^\circ$ , T. Carnelley (8), resolidifying at  $338^\circ$ , Schaffgotsch (9), or at  $332^\circ$ , T. Carnelley (10). When potassium nitrate is heated under pressure, it will stand redness without decomposition, Karsten (11); otherwise it decomposes, forming at first potassium nitrite, mixed with free alkali and undecomposed nitrate, N. W. Fischer (1)†, some nitrate remaining even after long heating, J. Lang (2), and finally a mixture of protoxide and peroxide of potassium (3).

*Silver Nitrate.  $AgNO_3$ .*

Silver nitrate melts  $198^\circ$ , Pohl (4), at  $219^\circ$  (5), at  $217-218^\circ$  T. Carnelley (6), or at  $233^\circ$ , T. Carnelley, (7), resolidifying at  $212^\circ$ , Carnelley (8), and decomposes at an incipient red-heat into oxygen, peroxide of nitrogen, nitrogen and metallic silver (9). When the

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\* (1) Amer. J. Sci. [2] 27. 14. Jahresb. 12. 114. Gmelin-Kraut 3. 556. (2) Watts Dict. 4. 97. (3) Watts Dict. 4. 99. (4) Ann. Chim. Phys. 21. 295. Pogg. Ann. 74. 522. 70. 301. Compt. rend. 23, 162. Annalen 64, 179. Jahresb. 1. 73. Gmelin-Kraut 2. 1. 91. Ros. and Sch. 2. 1. 80. Miller 340. (5) Pogg. Ann. 135. 642. Jahresb. 21. 20. Gmelin-Kraut 2. 1. 91. (6) Chem. Soc. J. 33. 273. (7) Pogg. Ann. 154. 190. (8) Chem. Soc. J. 31. 381. Zeitschr. Anal. Chem. 19. 175. (9) Pogg. Ann. 102. 293. Jahresh. 10. 18. Gmelin Kraut 2. 1. 91. (10) Chem. Soc. J. 29, 499. (11) Ph. Ch. Ber. 1843. 277. Gmelin-Kraut 2. 1. 92.

† (1) Pogg. Ann. 74. 115. Annalen 68. 224. J. pr. Chem. 46. 318. Pharm. Centr. 1848. 401. Chem. Gaz. 6. 281. Jahresh. 1. 383. (2) Pogg. Ann. 118. 282. J. pr. Chem. 86. 295. J. Ph. Chim. [3] 43. 341. Rep. Chim. pure. 5. 77. Jahresh. 15. 99. Gmelin-Kraut 2. 1. 92. (3) Gmelin-Kraut 2. 1. 91. Watts Dict. 4. 99. Miller 340. (4) Wien. Akad. Ber. 6. 587. Gmelin-Kraut 3. 953. Jahresh. 4. 59. Ros. and Sch. 2. 1. 377. (5) Watts Dict. 4. 104. Miller 686. (6) Chem. Soc. J. 33. 218. (7) Chem. Soc. J. 31. 381. Zeitschr. Anal. Chem. 19. 175. (8) Chem. Soc. J. 33. 273. (9) Gmelin-Kraut 3. 954.

salt is heated in a small retort until gas bubbles are evolved and red vapors begin to appear, oxygen gas is given off, and the residue consists of the nitrite, undecomposed nitrate, and a little metallic silver, J. Persoz (10).

*Sodium Nitrate.  $\text{NaNO}_3$ .*

Sodium nitrate melts at  $310.5^\circ$ , C. Person (1),\* at  $314^\circ$ , Braun (2), at  $316^\circ$ , T. Carnelley (3), or at  $330^\circ$ , T. Carnelley (4), solidifying again at  $313^\circ$ , Schaffgotsch (5). Sodium nitrate, when subjected to a red heat, evolves at first oxygen under the formation of the nitrite, Mitscherlich (6), then a mixture of oxygen, nitrogen and some peroxide of nitrogen (7), or protoxide of nitrogen, H. Deville and H. Debray (8), and finally forms a mixture of protoxide and peroxide of sodium (9). The nitrite that is formed by subjecting the nitrate of sodium to a red heat is always contaminated with some undecomposed nitrate and some free alkali, N. W. Fischer (10), J. Lang (11).

*Strontium Nitrate.  $\text{Sr}(\text{NO}_3)_2$ .*

Strontium nitrate crystallized with 4 mol. of water ( $\text{Sr}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$ ) melts when heated under the separation of the anhydrous salt, Ordway (1),† losing its water at  $100^\circ$ , A. Souchay and E. Lensen (2), Brooke (3).

The anhydrous salt decrepitates when heated (4), melts at  $645^\circ$ , T. Carnelley (5), decomposes and leaves a residue of strontia (6),

Ros. and Sch. 2. 1. 377. (10) Ann. Chin. Phys. [3] 23. 48. Chem. Soc. J. 1. 189. Annalen 65. 177.

\* (1) Ann. Chim. Phys. 21. 295. Pogg. Ann. 70. 800. 74. 523. Annalen 64. 179. Jahresb. 1. 73. Gmelin-Kraut 2. 1. 218. Watts Dict. 4. 106. Ros. and Sch. 2. 1. 80. Miller 361. (2) Pogg. Ann. 154. 190. (3) Chem. Soc. J. 33. 273. (4) Chem. Soc. J. 29. 489. Zeitschr. Anal. Chem. 17. 469. Ros. and Sch. 2. 1. 80. (5) Pogg. Ann. 102. 293. Jahresb. 10. 18. Gmelin-Kraut 2. 1. 218. (6) Gmelin-Kraut. 1. 2. 459. 2. 1. 218. (7) Gmelin-Kraut 2. 1. 218. (8) Ann. Chim. Phys. [3] 61. 117. (9) Watts Dict. 4. 106. (10) Pogg. Ann. 74. 115. Annalen 68. 224. J. pr. Chem. 46. 815. Pharm. Centr. 1848. 401. Chem. Gaz. 6. 281. Jahresb. 1. 383. (11) Pogg. Ann. 74. 118. 281. J. pr. Chem. 86. 295. J. Ph. Chim. [3] 42. 841. Rep. Chim. pure. 5. 77. Jahresb. 15. 100.

† (1) Amer. J. Sci. [2] 27. 14. Jahresb. 12. 113. Gmelin-Kraut 2. 1. 339. (2) Annalen 29. 45. J. pr. Chem. 69. 384. Gmelin-Kraut 2. 1. 339. (3) Gmelin-Kraut 2. 1. 339. (4) Gmelin-Kraut 2. 1. 339. Watts Dict. 4. 106. Ros. and Sch. 2. 1. 216. Miller 406. (5) Chem. Soc. J. 33. 273. (6) Gmelin-Kraut 2. 1.



under the evolution of oxygen and nitrogen (7). The nitrite is formed by the ignition of the nitrate, but is always contaminated with some free strontia, N. W. Fischer (8), and some undecomposed nitrate, J. Lang (9). The nitrite is formed by keeping the nitrate at its melting point, Hampe (10).

*Zinc Nitrate.*  $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ .

Zinc nitrate crystallized with 6 mol. of water melts at  $36.4^\circ$ , boils at  $131^\circ$ , and on long boiling remains clear until 42 per cent. of its weight has been lost; the residue on cooling consisting of  $4\text{ZnO} \cdot 3\text{N}_2\text{O}_5 \cdot 3\text{H}_2\text{O}$ , Ordway (1).\*

When the salt is heated for some time at  $100^\circ$  it loses nitric acid and water and a basic salt remains,  $9\text{ZnO} \cdot 2\text{N}_2\text{O}_5$ , A. Vogel and C. Reischauer (2); there is also evolved peroxide of nitrogen and oxygen, Schindler (3); and at  $105^\circ$  in a stream of air it loses nearly all its water, Pierre (4). After the salt is boiled and cooled the residue consists of  $\text{ZnO} \cdot 3\text{Zn}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$ , Gerhardt (5), and if the heat be continued until the salt becomes nearly solid, the residue contains  $8\text{ZnO} \cdot \text{N}_2\text{O}_5 \cdot 2\text{H}_2\text{O}$ , Grouvelle (6).

### THE NITRITES.

*Ammonium Nitrite.*  $\text{NH}_4\text{NO}_2$ .

Ammonium nitrite detonates when heated between  $60$  and  $70^\circ$ , Berthelot (1),† and is decomposed by a gentle heat, N. W. Fischer (2), into nitrogen and water,  $\text{NH}_4\text{NO}_2 = \text{N}_2 + 2\text{H}_2\text{O}$  (3), or into water, nitrous oxide and ammonia (4).

339. Watts Dict. 4. 106. (7) Miller 406. (8) Pogg. Ann. 74. 115. Annalen 68. 224. J. pr. Chem. 46. 318. Pharm. Centr. 1848. 401. Chem. Gaz. 6. 281. Jahresb. 1. 383. Gmelin-Kraut 2. 1. 339. (9) Pogg. Ann. 118. 282. J. pr. Chem. 86. 295. J. Ph. Chim. [3] 42. 341. Rep. Chim. pure. 5. 77. Jahresb. 15. 100. Gmelin-Kraut 2. 1. 339. (10) Annalen 125. 337. Jahresb. 16. 160. Gmelin-Kraut 2. 1. 339.

\* (1) Amer. J. Sci. [2] 27. 14. Jahresb. 12. 113. Gmelin-Kraut 3. 34. (2) N. Jahrb. Pharm. 11. 137. Jahresb. 12. 196. Gmelin-Kraut 3. 34. Ros. and Sch. 2. 1. 262. (3) Gmelin-Kraut 3. 34. (4) Ann. Chim. Phys. [3] 16. 247. Gmelin-Kraut 3. 35. Watts Dict. 4. 107. (5) J. Ph. Chim. [3] 12. 61. Jahresb. 1. 436. Watts Dict. 4. 107. (6) Ann. Chim. Phys. 19. 137. Gmelin-Kraut 3. 34.

† (1) J. Ph. Chim. [4] 19. 428. Bull. Soc. Chim. [2] 21. 55. Chem. Soc. J. 27. 961. 1058. Chem. Centr. 1874. 245. Jahresb. Ph. Tox. 1877. 270. (2) Pogg. Ann. 74. 119. Annalen 68. 224. J. pr. Chem. 46. 318. Pharm. Centr. 1848. 401. Jahresb. 1. 383. (3) Watts Dict. 1. 192. Ros. and Sch. 2. 1. 180. (4)

*Cadmium Nitrite.*  $Cd(NO_2)_2 \cdot H_2O$ .

Cadmium nitrite is decomposed even by a gentle heat, N. W. Fischer (2), or is decomposed at  $100^\circ$ , forming thereby a basic salt, J. Lang (5).

*Cobaltous Nitrite.*  $CoNO_2$ .

Cobaltous nitrite is decomposed even by a gentle heat, N. W. Fischer (2).

*Cupric Nitrite.*  $Cu(NO_2)_2$ .

Cupric nitrite is decomposed even by a gentle heat, N. W. Fischer, (6). A solution of the salt evolves nitric oxide even at an ordinary temperature, W. Hampe (7).

*Lead Nitrite.*  $Pb(NO_2)_2 \cdot H_2O$ .

Lead nitrite is easily decomposed, N. W. Fischer (1),\* Peligot (2), and when heated at  $100^\circ$  evolves nitric oxide and leaves a basic salt behind, J. Lang (3).

*Magnesium Nitrite.*  $Mg(NO_2)_2 \cdot 2H_2O$ .

Magnesium nitrite is easily decomposed by heat, N. W. Fischer (1), evolving nitric oxide even at  $100^\circ$ , S. Lang (4), and after being heated to redness leaves 26.14 per cent. of magnesium oxide, W. Hampe (5).

*Mercurous Nitrite.*  $Hg_2(NO_2)_2$ .

Mercurous nitrite, when exposed to the action of heat, resists a temperature of  $280^\circ$  but at  $290^\circ$  it begins to give off red vapors, J. Lefort (6).

Gmelin. Watts Transl. 2. 490. (5) Pogg. Ann. 98. 291. J. pr. Chem. 86. 295. J. P. Chim. [3] 42. 341. Rep. Chim. pure. 5. 77. Jahresb. 15. 100. Gmelin-Kraut 3. 73. Watts Dict. 4. 72. (6) Pogg. Ann. 74. 121. Annalen 68. 224. J. pr. Chem. 46. 318. Pharm. Centr. 1848. 401. Jahresb. 1. 383. Gmelin-Kraut 3. 650. (7) Annalen 125. 343. Jahresb. 16. 162. Gmelin-Kraut 3. 650.

\* (1) Pogg. Ann. 74. 121. Annalen 68. 224. J. pr. Chem. 46. 318. Pharm. Centr. 1848. 401. Jahresb. 1. 383. (2) Ann. Chim. Phys. [3] 2. 87. Annalen 39. 338. (3) Pogg. Ann. 118. 282. J. pr. Chem. 86. 295. J. P. Chim. [3] 42. 341. Rep. Chim. pure. 5. 77. Jahresb. 15. 100. Gmelin-Kraut 3. 257. (4) Pogg. Ann. 118. 289. J. pr. Chem. 86. 295. J. P. Chim. [3] 42. 341. Rep. Ch. pure. 5. 77. Jahresb. 15. 100. Gmelin-Kraut 2. 1. 473. (5) Annalen 125. 341. Jahresb. 16. 160. (6) Compt. rend. 1845. July 7. Chem. Gaz., 3. 342.

*Nickelous Nitrite.  $Ni(NO)_2$ .*

Nickelous nitrite is not decomposed at  $100^\circ$ , J. Lang (7), but when heated to redness it loses its acid, and leaves behind the oxide of nickel, J. Lang (1).\* W. Hampe (2).

*Silver Nitrite.  $AgNO_2$ .*

Silver nitrite does not lose in weight at  $100^\circ$ , but begins to decompose at  $140$ – $150^\circ$ , J. Lang (3). When gently heated in a glass tube it decomposes into metallic silver and nitrous acid (4), or evolves hyponitric acid, which converts the residue into silver nitrate, Peligot (5). When silver nitrite is heated in an open dish over a lamp, or in an air bath, between  $85$  and  $140^\circ$ , it decomposes into metallic silver, tri-oxide of nitrogen and silver nitrate, a little of the nitrite remaining undecomposed,  $3AgNO_2 = N_2O_3 + Ag_2 + AgNO_3$ . When a closely covered crucible is used, there is formed nitric oxide instead of the tri-oxide of nitrogen,  $2AgNO_2 = NO + Ag + AgNO_3$ . When heated in a test tube, accurately stopped with a glass rob, red fumes appear at  $115^\circ$ ; the crystals begin to shrink and fuse at  $134^\circ$ , and  $\frac{1}{2}$  the salt is decomposed into metallic silver, nitric oxide and oxygen, Ed. Divers (6).

*Zinc Nitrite.  $Zn(NO_2)_2 \cdot 3H_2O$ .*

Zinc nitrite is decomposed even by a gentle heat, N. W. Fischer (1),† and when heated at  $100^\circ$  evolves nitric oxide and leaves a basic salt, which at a higher temperature loses its acid and is converted into the oxide, J. Lang (2). When Zinc nitrite is heated to redness the oxide remains, W. Hampe (3).

(7) Pogg. Ann. 118. 282. J. pr. Chem. 86. 295. J. P. Chim. [3] 42. 341. Rep. Ch. pure. 5. 77. Jahresb. 15. 100. Gmelin-Kraut 3. 555.

\* (1) Pogg. Ann. 118. 282. J. pr. Chem. 86. 295. J. P. Chim. [3] 42. 341. Rep. Ch. pure. 5. 7. Jahresb. 15. 100. (2) Annalen 125. Jahresb. 16. 160. (3) Pogg. Ann. 118. 118. 292. J. pr. Chem. 86. 295. J. P. Chim. [3] 42. 341. Rep. Ch. pure. 5. 77. Jahresb. 15. 100. Gmelin-Kraut 3. 952. (4) Gmelin-Kraut 3. 952. 1. 2. 459. (5) Ann. Chim. Phys. [3] 2. 68. Gmelin-Kraut 1. 2. 459. (6) Chem. Soc. J. 24. 85. Bull. Soc. Chim. [2] 15. 178. Ber. 4. 282. Amer. Chem. 2. 71. Jahresb. 24. 343.

† (1) Pogg. Ann. 74. 121. Annalen 68. 224. J. pr. Chem. 46. 318. Pharm. Chem. 1848. 401. Jahresb. 1. 883. (2) Pogg. Ann. 118. 289. J. pr. Chem. 86. 295. J. P. Chim. [3] 42. 341. Rep. Ch. pure. 5. 77. Jahresb. 15. 100. Gmelin-Kraut 3. 34. (3) Annalen 125, 344. Jahresb. 16. 160.

## THE PHOSPHATES.

*Aluminium Phosphate.*  $Al_2(PO_4)_3$ .

Aluminium phosphate does not melt at a red heat, Ludwig (1).\*

*Ammonium Phosphate.*  $(NH_4)_2PO_4$ .

Ammonium phosphate cannot be dried without losing ammonia and being converted into diammonic phosphate (2), which when heated first undergoes fusion, then dries up, and at a red heat is converted with slow and imperfect expulsion of ammonia into hydrated phosphoric acid (3), or into meta phosphoric acid,  $(NH_4)_2HPO_4 = HPO_3 + 2NH_3 + H_2O$  (2).

*Barium Phosphate.*

Mono-basic phosphate of barium  $(BaH_2(PO_4)_2)$ , when heated, melts to a colorless glass, Erlenmeyer (4), or by melting forms a white, spongy mass, similar to alum, and at a red heat leaves behind meta-phosphate of barium, Berzelius (5).

Di-basic phosphate of barium  $(BaHPO_4)$  melts in the heat, Berzelius (6), loses no water at  $300^\circ$ , and becomes anhydrous only at a red heat, A. Chodnew (7).

*Cadmium Phosphate.*  $Cd_2(PO_4)_2$ .

Cadmium phosphate melts at an incipient white heat forming a transparent vitreous mass, Stromeyer (1).†

*Calcium Phosphate.*  $Ca_3(PO_4)_2$ .

Normal phosphate of calcium can be melted at a very high red heat to a porcelain-like mass, Saussure (2).

The precipitated salt retains 1 mol. of water at  $100^\circ$ , becomes anhydrous at  $200^\circ$ , and is not decomposed by simple ignition (3).

Mono-basic phosphate of calcium  $(CaH_2(PO_4)_2)$  melts when heated, giving off all its water and leaving an insoluble meta-phosphate (4),  $CaH_2(PO_4)_2 = CaP_2O_6 + 2H_2O$  (5). The same with 1 mol. of water of crystallization  $(CaH_2(PO_4)_2 \cdot H_2O)$  loses 17.2 per cent. of its water

\* (1) Arch. Pharm. [2] 59. 19. Pharm. Centr. 1850. 109. Gmelin-Kraut 2. 1. 633. (2) Watts Dict. 1. 193. (3) Gmelin. Watts Transl. 2. 442. (4) Jahresb. 10. 145. Gmelin-Kraut 2. 1. 273. (5) Ann. Chim. Phys. 2. 153. Gmelin-Kraut 2. 1. 274. (6) Gmelin-Kraut 2. 1. 272. (7) J. pr. Chem. 29. 201.

† (1) Ann. Chim. Phys. 11. 81. Gmelin-Kraut 3. 66. Watts Dict. 4. 554. (2) Gmelin-Kraut 2. 1. 366. (3) Watts Dict. 4. 556. (4) Watts Dict. 4. 555. (5)

at 200°, and is converted into pyro-phosphate of calcium and meta-phosphoric acid,  $2\text{CaH}_2(\text{PO}_3)_2 \cdot \text{H}_2\text{O} = \text{Ca}_2\text{P}_2\text{O}_7 + \text{H}_2\text{P}_2\text{O}_7 + 5\text{H}_2\text{O}$ , which by further heating swells up, melts, loses the rest of the water, and at a red heat is converted into meta-phosphate of calcium, K. Birnbaum (6).

Di-basic phosphate of calcium ( $\text{CaHPO}_4$ ), when subjected to a red heat, loses water and is changed into a pyrophosphate, Debray (1).<sup>\*</sup> The same with 2 mol. of water of crystallization ( $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$ ) loses the 2 mol. at 140°, Percy (2), or at 150°, and the last traces of waters at a red heat, Bodeker (3), leaving behind a somewhat porous, white, opaque mass, Erlenmeyer (4).

*Chromium Phosphate.*  $\text{Cr}_2(\text{PO}_4)_3 \cdot 12\text{H}_2\text{O}$ .

Phosphate of chromium with 12 mol. of water loses, when heated, 7 mol. of water and is converted into the green phosphate, A. Etard (5).

*Cobaltous Phosphate.*

Cobaltous phosphate is of a pink color, and when heated loses its water and becomes bluish-pink, Alvaro Reynoso (6).

*Cupric Phosphate.*  $\text{Cu}_2(\text{PO}_4)_2 \cdot 3\text{H}_2\text{O}$ .

Cupric phosphate changes in the heat from a bluish-green to a dark brown powder under loss of water (7).

*Ferric Phosphate.*  $\text{Fe}_2(\text{PO}_4)_3 \cdot 4\text{H}_2\text{O}$ .

Ferric phosphate, when heated, becomes yellow and melts at a red heat, Bergman (1),<sup>†</sup> becoming anhydrous, Millot (2).

Watts Dict. 4. 500. (6) Zeitschr. Chem. 1871. 137. Jahresb. 24. 281. Gmelin-Kraut 2. 1. 373.

<sup>\*</sup> (1) Ann. Chim. Phys. [3] 61. 424. Gmelin-Kraut 2. 1. 371. (2) Watts Dict. 4. 555. (3) Annalen 69. 206. Pharm. Centr. 1849. 282. Chem. Gaz. 7. 138. Jahresb. 2. 229. (4) N. Jahrb. Pharm. 7. 225. Jahresb. 10. 145. (5) Compt. rend. 84. 1089. Gmelin-Kraut 2. 2. 304. Jahresb. 30. 261. (6) Ann. Chim. Phys. [3] 45. 110. (7) Gmelin-Kraut 3. 615.

<sup>†</sup> (1) Opusc. 3. 118. Gmelin-Kraut 3. 327. Watts Dict. 4. 563. (2) Compt. rend. 82. 89. Pharm. J. Trans. [3] 7. 118. Jahresb. 29. 244. Ros. and Sch.

*Lead Phosphate.*

Di-basic phosphate of lead ( $\text{PbHPO}_4$ ), when heated to redness, remains white, gives off water, and changes into the anhydrous pyrophosphate,  $\text{Pb}_2\text{P}_2\text{O}_7$  (3).

*Magnesium Phosphate.  $\text{Mg}_3(\text{PO}_4)_2 \cdot 5\text{H}_2\text{O}$ .*

Normal magnesium phosphate with 5 mol. of water melts at a white heat to a clear glass, Graham (4), Gregory (5), and becomes anhydrous on ignition (6).

Di-basic phosphate of magnesium with 14 mol. of water ( $\text{MgHPO}_4 \cdot 14\text{H}_2\text{O}$ ) loses 8 mol. of water at  $100^\circ$ ; 6 more at  $176^\circ$ , and yields its basic water at a stronger heat under the formation of the pyrophosphate, Graham (7).

*Manganous Phosphate.  $\text{Mn}_3(\text{PO}_4)_2 \cdot 7\text{H}_2\text{O}$ .*

Normal manganous phosphate with 7 mol. of water loses 4 mol. at  $100^\circ$ , Erlenmeyer and Heinrich (8), or at  $110^\circ$ – $120^\circ$ , and the last 3 only at a red heat, Heintz (9).

Mono-basic phosphate of manganese ( $\text{MnH}_2(\text{PO}_4)_2 \cdot 2\text{H}_2\text{O}$ ), when heated at  $100^\circ$ , not only loses water, Erlenmeyer and Heinrich (1),\* but also a part undergoes decomposition with the separation of phosphoric acid, which at a higher temperature volatilizes, E. Erlenmeyer and O. Heinrich (2). The salt loses at  $110$ – $120^\circ$  on an average 13.15 per cent. of water, and at a red heat 12.91 per cent., Heintz (3).

Di-basic phosphate of manganese with 6 mol. of water ( $\text{Mn}_2\text{H}_2(\text{PO}_4)_3 \cdot 6\text{H}_2\text{O}$ ), when heated at  $100^\circ$ , loses 22.24 per cent. of water, Erlenmeyer and Heinrich (4); at  $110^\circ$ , 23.27 per cent., Bödeker (5); at  $110$ – $120^\circ$ , 22.47 per cent., Heintz (6); at  $200^\circ$  the 6 mol. are evolved, Heintz (6), and at a red heat pyrophosphate of manganese ( $\text{Mn}_2\text{P}_2\text{O}_7$ ) is left, Bödeker (7), Debray (8).

2. 2. 102. (3) Gmelin-Kraut 3. 227. (4) Gmelin-Kraut 2. 1. 445. (5) Annalen 54. 98. Gmelin-Kraut 2. 1. 455. (6) Watts Dict. 4. 569. (7) Gmelin-Kraut 2. 1. 447. (8) Annalen 190. 208. Jahresb. 30. 255. (9) Pogg. Ann. 74. 449. 75. 174. Annalen 48. 257. Pharm. Centr. 1848. 657. J. Ph. Chim. [3] 14. 397. Chem. Gaz. 6. 488. Jahresb. 1. 342.

\* (1) Annalen 190. 195. Chem. Soc. J. 33. 270. Jahresb. 30. 255. Gmelin-Kraut 2. 2. 474. (2) Annalen 190. 191. (3) Pogg. Ann. 74. 450. Gmelin-Kraut 2. 2. 474. (4) Annalen 190. 191. Gmelin-Kraut 2. 2. 474. (5) Annalen 69. 208. Pharm. Centr. 1849. 283. Gmelin-Kraut 2. 2. 474. (6) Pogg. Ann. 74. 450. Gmelin-Kraut 2. 2. 474. (7) Annalen 69. 308. Gmelin-Kraut 2. 2. 474. (8) Ann. Chin. Phys. [3] 6. 453. Gmelin-Kraut 2. 2. 474.

*Mercuric Phosphate.  $Hg_2(PO_4)_2$ .*

Mercuric phosphate, when heated, cakes up and melts to a dark yellow liquid, opaque when cold ; at a stronger heat metallic mercury, oxygen and phosphorous oxide are evolved and a residue is left behind, which is not only acid in reaction and insoluble in water, but also contains mercuric oxide, which by a still longer heating is completely volatilized, Trommsdorff (1)\*. The dry salt melts, when heated, to a dark yellow glass (2).

*Mercurous Phosphate.  $Hg_2(PO_4)_2$ .*

Mercurous phosphate, when gently heated in a tube, evolves metallic mercury and leaves mercuric phosphate as a residue, Gerhardt (3).

*Nickelous Phosphate.  $Ni_3(PO_4)_2 \cdot 7H_2O$ .*

Nickelous phosphate with 7 mol. of water gives off water at a low red heat and becomes yellow, Rammelsberg (4) ; but after a long continued heat it becomes brown without loss in weight, Struve (5).

*Potassium Phosphate.  $K_2PO_4$ .*

Normal phosphate of potassium, when strongly heated, melts to an enamel-like mass (6).

Mono-basic phosphate of potassium ( $KH_2PO_4$ ) undergoes no change at  $200^\circ$  ; but when heated nearly to redness is converted without melting into the metaphosphate, Graham (7), or melts to a clear glass, which on cooling consists of mono-metaphosphate of potassium,  $KPO_3$ , (1)†.

Di-basic phosphate of potassium ( $K_2HPO_4$ ) is converted into the pyro-phosphate by ignition, Graham (2).

*Silver Phosphate.  $Ag_3PO_4$ .*

Silver phosphate melts at a strong red heat, Berzelius (3), to a dark brown fluid, which on cooling becomes yellow, and which a portion by longer melting is transformed into pyrophosphate of

\* (1) Gmelin-Kraut 3. 754. (2) Watts Dict. 4. 573. (3) Compt. rend. 1849. 225. Jahresb. 2. 288. Gmelin-Kraut 3. 753. Watts Dict. 4. 573. (4) Pogg. Ann. 68. 383. Gmelin-Kraut 3. 543. Watts Dict. 4. 544. (5) Gmelin-Kraut 3. 543. (6) Watts Dict. 4. 575. Ros. and Sch. 2. 1. 89. (7) Watts Dict. 4. 574.

† (1) Gmelin-Kraut 2. 1. 30. (2) Gmelin-Kraut 2. 1. 31. Watts Dict. 4. 575. (3) Gmelin-Kraut 3. 918. Watts Dict. 4. 576. Ros. and Sch. 2. 1. 379. Miller

silver, Stromeyer (4). When the salt is heated in a platinum crucible below redness, it deepens in color, becoming a dark orange-brown, but recovering its original color on cooling, Alvaro Reynoso, (5), Berzelius (6).

Di-basic phosphate of silver ( $\text{Ag}_2\text{HPO}_4$ ) loses no water at  $100^\circ$ , but at  $170^\circ$  it loses 2.87 per cent. under the formation of pyrophosphate of silver, Schwarzenberg (7).

*Sodium Phosphate.  $\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$ .*

Normal sodium phosphate with 12 mol. of water melts at  $76.7^\circ$  (1)\*, retains 1 mol. of water at  $100^\circ$ , which it does not entirely yield at  $200^\circ$ ; but gives it up at a red heat only after repeated pulverization and heating, Gerhardt (2), Graham (3).

Sodium phosphate with 10 mol. of water ( $\text{Na}_3\text{PO}_4 \cdot 10\text{H}_2\text{O}$ ) melts at  $100^\circ$ , loses at  $110^\circ$  48.70 per cent. of water, the rest of which, 2.46 per cent., is still retained at  $150^\circ$ , but is expelled at red heat, Rammelsberg (4).

Mono-basic phosphate of sodium ( $\text{NaH}_2\text{PO}_4 \cdot 4\text{H}_2\text{O}$ ) loses its water of crystallization at  $100^\circ$ ; at  $190$ – $204^\circ$  it evolves  $\frac{1}{2}$  its water of constitution.  $2\text{NaH}_2\text{PO}_4 = \text{NaH}_2\text{P}_2\text{O}_7$ ; at  $204$ – $244^\circ$  evolves the rest, forming mono-metaphosphate,  $\text{NaH}_2\text{PO}_4 = \text{NaPO}_3 + \text{H}_2\text{O}$ ; and at a red heat there remains the hexa-meta phosphate of sodium,  $\text{Na}_6\text{P}_6\text{O}_{18}$  (5). When the salt is quickly heated to  $204^\circ$ , the crystals partially melt, Graham (6).

Di-basic phosphate of Sodium ( $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$ ) melts at  $35^\circ$ . H. Kopp (7), or at  $36.4$ , C. C. Person (8), loses its water of crystallization at  $45^\circ$  (1)† and at a red heat it is transformed into the pyrophosphate, Clark (2); this change takes place at  $240^\circ$ , and in fact

687. (4) Schw. 58. 126. Gmelin-Kraut 3. 918. (5) Ann. Chim. Phys. [3] 45. 110. Gmelin-Kraut 3. 918. Watts Dict. 4. 576. (6) Gmelin-Kraut 3. 918. (f) Annalen 65. 162. Gmelin-Kraut 3. 919.

\* (1) Gmelin-Kraut 2. 1. 163. Ros. and Sch. 2. 1. 121. (2) J. Ph. Chim. [3] 12. 57. Jahresb. 1. 338. Gmelin-Kraut 2. 1. 163. (3) Gmelin-Kraut 2. 1. 163. (4) J. pr. Chem. 94. 237. Jahresb. 17. 185. Gmelin-Kraut 2. 1. 163. (5) Gmelin-Kraut 2. 1. 167. Watts Dict. 4. 579. Ros. and Sch. 2. 1. 123. (6) Gmelin-Kraut 2. 1. 167. (7) Annalen 93. 129. Pharm. Centr. 1855. 219. Instit. 1855. 260. Phil. Mag. J. [4] 9. 477. Jahresb. 8. 45. Gmelin-Kraut 2. 1. 165. Watts Dict. 4. 579. Ros. and Sch. 2. 1. 122. (8) Ann. Chim. Phys. [3] 27. 250. Pogg. Ann. 70. 801. Compt. rend. 23. 162. Annalen 64. 179. Jahresb. 1. 72. 2. 32. Gmelin-Kraut 2. 1. 165.

† (1) Ros. and Sch. 2. 1. 122. (2) Schw. 57. 428. Gmelin-Kraut 2. 1. 165.



the water cannot be driven off without the formation of the pyrophosphate, Rose (3).

*Strontium Phosphate.*

Di-basic phosphate of Strontium ( $\text{SrHPO}_4$ ) is converted at a red heat into the pyro-phosphate,  $\text{Sr}_2\text{P}_2\text{O}_7$ , (4).

*Zinc Phosphate.  $\text{Zn}_3(\text{PO}_4)_2 \cdot 2\text{H}_2\text{O}$ .*

Zinc phosphate with 2 mols. of water melts easily, forming a transparent, colorless liquid (5).

THE SULPHATES.

*Aluminium Sulphate.  $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$ .*

Aluminium sulphate, crystallized with 18 mol. of water, melts when heated in its water of crystallization (1)\*, which it loses at  $120^\circ$  without changing in appearance, Hager (2), or under strong inflation, Berzelius (3), and at a red heat pure aluminium oxide remains. The anhydrous salt when heated to redness over a gas flame leaves the basic salt,  $\text{Al}_2\text{O}_3\text{SO}_3$ , Stolba (4).

*Ammonium Sulphate.  $(\text{NH}_4)_2\text{SO}_4$ .*

Ammonium sulphate decrepitates when heated (5), melts at  $140^\circ$  and begins to decompose at  $280^\circ$ , Marchland (6). At a temperature a little higher than the boiling point of mercury, ammonia and water are given off, while a mixture of the pyro-sulphate with the normal and acid sulphate is left,  $6(\text{NH}_4)_2\text{SO}_4 = 5\text{NH}_3 + \text{H}_2\text{O} + 3\text{NH}_4\text{HSO}_4 + (\text{NH}_4)_2\text{S}_2\text{O}_7 + (\text{NH}_4)_2\text{SO}_4$ . Near incipient redness the action is expressed by the following equation:  $3[\text{NH}_4\text{HSO}_4 + (\text{NH}_4)_2\text{S}_2\text{O}_7 + (\text{NH}_4)_2\text{SO}_4] = 2\text{SO}_3 + 2\text{H}_2\text{O} + 3\text{NH}_3 + 2\text{NH}_4\text{HSO}_4 + (\text{N}_2\text{H}_4)_2\text{S}_2\text{O}_7$ , S. W. Johnson and R. H. Crittenden (7).

At a little above the boiling of mercury ammonium sulphate loses  $\frac{1}{2}$  its ammonia, forming the bi-sulphate,  $(\text{NH}_4)_2\text{SO}_4 = \text{NH}_4\text{HSO}_4 + \text{NH}_3$ ; and then below incipient redness it loses ammonia and

Watts Dict. 4. 579. (3) Pogg. Ann. 76. 13. Gmelin-Kraut 2. 1. 165. (4) Gmelin-Kraut 2. 1. 325. (5) Watts Dict. 4. 587.

\* (1) Watts Dict. 5. 579. Ros. and Sch. 2. 1. 449. (2) Pharm. Centr. 12. 476. Jahresb. Ph. Tox. 1871. 233. (3) Gmelin-Kraut 2. 1. 639. Watts Dict. 5. 579. Ros. and Sch. 2. 1. 449. (4) Chem. Centr. 1874. 135. Gmelin-Kraut 2. 1. 638. (5) Gmelin. Watts Transl. 2. 462. Miller 392. (6) Pogg. Ann. 40. 556. Gmelin. Watts transl. 2. 462. Watts Dict. 1. 193. Miller 392. (7) Amer. J. Sci. [3] 15. 131. Chem. Soc. J. 33 and 34 (Abs.) 873.

acid both,  $4(\text{NH}_4\text{HSO}_4) = (\text{NH}_4)_2\text{H}_2(\text{SO}_4)_2 + \text{SO}_2 + 2\text{H}_2\text{O} + 4\text{H}$ , Pau<sup>1</sup> Schweitzer (1).\*

The salt after melting consists of the acid sulphate of ammonium, H. Rose (2). When the salt is heated in a retort a sublimate of the sulphite and sulphate is obtained, H. Rose (3); but before the sublimation takes place, ammonia, water and nitrogen are evolved (4).

*Antimonous Sulphate.*  $\text{Sb}_2(\text{SO}_4)_3$ .

Antimonous sulphate when heated to redness, gives off sulphuric anhydride, C. Schultz-Sellack (5), Bussy (6), or sulphurous anhydride and oxygen, Gay-Lussac (6), and often yields a sublimate of antimonious oxide in the form of needles, Birchloz (6).

*Barium Sulphate.*  $\text{BaSO}_4$ .

Barium sulphate melts at  $35^\circ$ , Wedgw., Saussure (7), undergoes a partial decomposition when heated over a Bunsen-gas-bellows, and in Schlösing's apparatus at the melting heat of iron it not only loses all its acid, but also a portion of its baryta, Boussingault (1).†

*Bismuth Sulphate.*  $\text{Bi}_2(\text{SO}_4)_3$ .

Bismuth sulphate can be heated almost to redness without decomposition, C. Schultz-Sellack (2).

*Cadmium Sulphate.*  $3\text{CdSO}_4 \cdot 8\text{H}_2\text{O}$ .

Crystallized cadmium sulphate loses nearly 3 mol. of water at  $100^\circ$ , and the remainder at a dull red heat without melting and without loss of any acid, Carl von Hauer (3). When the anhydrous sulphate of cadmium is subjected to a strong red heat,  $\frac{1}{2}$  its acid is expelled and a basic salt is left behind, Stromeyer (4), C. von Hauer (5). By long continued calcination a portion of the remaining acid is driven off; the mass is partially fused and appears brown from the formation of free oxide, C. von Hauer (5), this residue consists of the oxide and neutral sulphate of cadmium, O. Follenius (6).

\* (1) Chem. News. 86. 95. (2) Pogg. Ann. 82. 85. (3) Pogg. Ann. 82. 85. Gmelin. Watts transl. 2. 462. (4) Gmelin. Watts transl. 2. 462. Watts Dict. 1. 193. (5) Ber. 4. 13. Jahresb. 24. 828. Watts Dict. sup. 2. 1137. (6) Gmelin. Watts transl. 4. 861. (7) Gmelin-Kraut 2. 1. 287.

† (1) Compt rend. 64. 1159. Institut. 1867. 185. Ann. Chim. Phys. [4] 12. 424. Bull. Soc. Chim. [2] 8. 259. J. pr. Chem. 102. 90. Zeitschr. Anal. Chem. 7. 244. Jahresb. 20. 151. Gmelin-Kraut 2. 1. 287. (2) Ber. 4. 13. Jahresb. 24. 329. (3) Wien. Akad. Ber. 15. 23. Chem. Soc. J. 8. 251. Gmelin-Kraut 3. 68. Watts. Dict. 5. 585. (4) Ann. Chim. Phys. 11. 80. Gmelin-Kraut. 3. 69. (5) Wien. Akad. Ber. 15. 23. Chem. Soc. J. 8. 251. Gmelin-Kraut 3. 69. (6) Zeitschr. Anal. Chem. 13. 276.

The crystallized sulphate when heated in a vacuum at  $79^{\circ}$  loses 5 mol. of water and becomes anhydrous at  $110^{\circ}$ , H. Precht and K. Kraut (1).\*

*Calcium Sulphate.*  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ .

Powdered gypsum loses, although slowly, all its water at  $100^{\circ}$ , Kraut (2), even under  $100^{\circ}$ , Fr. Knapp (2), or does not lose any at  $100^{\circ}$ , T. Graham (3).

The crystallized sulphate of calcium loses  $\frac{2}{3}$  of its water at  $105$ – $110^{\circ}$ , Millon (4), at  $110$ – $115^{\circ}$ , Plessy (5), or at  $100$ – $120^{\circ}$  (6), and the whole is not expelled below  $132^{\circ}$ , T. Graham (3); but is given off at  $200$ – $250^{\circ}$ , Plessy, (7), at  $200$ – $300^{\circ}$ , Millon (4), or at  $110$ – $120^{\circ}$  (8). The precipitated gypsum loses its water in a steam bath, Gunning (9), Millon (10), Plessy (11). The anhydrous salt when heated at a white heat in an open or covered crucible, loses acid and leaves a residue containing free calcium oxide, Alexander Mitscherlich (12); but when heated over a Bunsen-gas-bellows or in Schlösing's apparatus at the melting heat of iron, the whole of its acid is expelled, and a residue of calcium oxide remains, Boussingault (1).†

*Chromium Sulphate.*  $\text{Cr}_2(\text{SO}_4)_3 \cdot 15\text{H}_2\text{O}$ .

Chromium sulphate with 15 mol. of water melts at  $100^{\circ}$  in its water of crystallization (2), of which it loses 10 mol., being thereby converted into the green sulphate (3).

The salt with 18 mol. of water ( $\text{Cr}(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$ ) changes, when heated, under loss of 12 mol. into the green sulphate, which at an incipient redness becomes anhydrous, A. Etard, (4).

\* (1) Annalen 178. 140. (2) Gmelin-Kraut 2. 1. 386. (3) Phil. Mag. J. [3] 6. 422. Trans. Roy. Soc. Ed. 13. 297. Pogg. Ann. 38. 123. J. pr. Chem. 5. 80. (4) Ann. Chim. Phys. [3] 19. 222. J. pr. Chem. 40. 363. Pharm. Centr. 1847. 395. Phil. Mag. J. [3] 30. 299. Jahresb. 1. 395. (5) Compt. rend. 24. 658. Jahresb. 1. 395. (6) Watts Dict. 5. 585. (7) Compt. rend. 24. 658. Jahresb. 1. 395. Watts Dict. 5. 285. (8) Ros. and Sch. 2. 1. 202. (9) Chem. Centr. 1871. 148. Gmelin-Kraut 2. 1. 386. (10) Ann. Chim. Phys. [3] 19. 222. Compt. rend. 24. 695. Gmelin-Kraut 2. 1. 386. (11) Compt. rend. 24. 658. 812. Jahresb. 1. 395. Gmelin-Kraut 2. 1. 386. (12) J. pr. Chem. 83. 485. Zeitschr. Anal. Chem. 1. 63. Jahresb. 14. 843. Gmelin-Kraut 2. 1. 384.

† (1) Ann. Chim. Phys. [4] 12. 419. Compt. rend. 64. 1159. Zeitschr. Anal. Chem. 7. 244. Gmelin-Kraut 2. 1. 384. (2) Miller 539. (3) Watts Dict. 5. 588. Miller 539. (4) Compt. rend. 84. 1089. Chem. News. 35. 253. Jahresb. 30.

The green sulphate of chromium on exposure to heat changes to a rose color with a faint violet tint, but recovers its green color on cooling, M. E. Kopp (5).

*Cobaltous Sulphate.*  $\text{CoSO}_4 \cdot 7\text{H}_2\text{O}$ .

Cobaltous sulphate, when heated at  $100^\circ$  until it ceases to lose in weight, suffers a loss of 6 mol. of water, at  $250^\circ$  becomes anhydrous, T. E. Thorpe and John I. Watts (6). When it is heated the salt, without melting, but with loss of water, becomes opaque and rose red in color, Proust (1).\*

*Cupric Sulphate.*  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ .

Crystallized sulphate of copper loses 4 mol. of water at  $100^\circ$ , T. Graham (2), and the last mol. at  $200^\circ$  (3), or at  $221\text{--}242^\circ$ . T. Graham (4). The anhydrous sulphate, when subjected to a dark red heat, loses  $\frac{1}{2}$  of its acid forming a basic salt, Roucher (5); but at a strong red heat it loses all its acid, giving off sulphurous anhydride and oxygen, Gay-Lussac (6), together with some sulphuric anhydride, Bussy (7), and leaving cupric oxide (8).

*Ferric Sulphate.*  $\text{Fe}_2(\text{SO}_4)_3$ .

Ferric sulphate at a bright red heat evolves sulphuric anhydride (9), and leaves pure oxide of iron, Peter Hart (10).

*Ferrous Sulphate.*  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ .

Ferrous sulphate, when heated, melts in its water of crystallization (1),† 6 mol. of which are expelled at  $114\text{--}115^\circ$ , and the last mol. is retained even at  $180^\circ$ , T. Graham (2); but at a red heat it de-

261. Gmelin-Kraut 2. 2. 309. (5) Compt. rend. June 17. 1844. Chem. Gaz. 2. 381. (6) Chem. Soc. J. 37. 112.

\* (1) Gmelin-Kraut 3. 452. (2) Phil. Mag. J. [3] 6. 418. Trans. Roy. Soc. Ed. 13. 297. J. pr. Chem. 5. 90. Pogg. Ann. 38. 123. Watts Dict. 5. 590. Ros. and Sch. 2. 1. 338. Miller 622. (3) Watts Dict. 5. 590. Miller 622. (4) Phil. Mag. J. [3] 5. 418. Trans. Roy. Soc. Ed. 13. 297. J. pr. Chem. 5. 90. Pogg. Ann. 38. 123. Gmelin-Kraut 3. 620. Ros. and Sch. 2. 1. 338. (5) J. Ph. Chim. [3] 37. 249. Zeitschr. Chem. Pharm. 1860. 462. Jahresb. 13. 193. Gmelin-Kraut 3. 629. (6) Gmelin-Kraut 3. 629. Watts Dict. 5. 590. (7) Gmelin-Kraut 3. 629. (8) Watts Dict. 5. 590. (9) Gmelin-Kraut 3. 346. (10) Chem. Gaz. 12. 350.

† (1) Gmelin-Kraut 3. 340. (2) Phil. Mag. J. [3] 6. 421. Trans. Roy. Soc. Ed.

composes, evolving sulphurous anhydride and leaving a basic sulphate, which at a higher temperature loses the whole of its acid, partly as sulphuric anhydride, and partly as sulphurous anhydride and oxygen, leaving a residue of ferric oxide (3). Ferrous sulphate loses 6 mol. of water when heated in a vacuum at 100°, H. Precht and K. Kraut (4), or at 140°, Mitscherlich (5), and can be rendered anhydrous if the heat be cautiously raised, T. Graham (6).

*Lead Sulphate..  $PbSO_4$ .*

Lead sulphate melts at a red heat (7), without decomposition (8), becoming crystalline on cooling (9); does not decompose at a very strong heat, Berthier (10); but when subjected to a white heat in an open crucible over a gas-bellows it loses all its acid, Boussingault (11).

When heated in a tightly covered vessel lead sulphate undergoes no change; but in an open or loosely covered one it suffers a change of color and loss in weight, Erdmann (1),\* O. L. Erdmann and R. E. Marchland (2).

*Magnesium Sulphate.  $MgSO_4 \cdot 7H_2O$ .*

Magnesium sulphate, when heated, melts in its water of crystallization (3), 1 mol. of which it loses at 40°, Mulder (4), or at 50° (5), 3.5 mol. at 60°, 5 mol. at 101°, 6 mol. at 201°, Mulder (4), at 131°, T. Graham (6), or at 150° (7), and the last mol. is retained at 130–140°, T. E. Thorpe and J. I. Watts (8), at 200° (7), or at 238. T. Graham (6), being expelled at 280°, T. E. Thorpe and J. I. Watts (8), or at 285° in the vacuum of Hofmann's apparatus, Ad. Schröder (9).

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13. 297. J. pr. Chem. 5. 90. Pogg. Ann. 38. 123. Gmelin-Kraut 3. 339. Watts Dict. 5. 597. (3) Gmelin-Kraut 3. 339. Watts Dict. 5. 597. Miller 522. (4) Annalen 178. 140. (5) Gmelin-Kraut 3. 339. (6) Phil. Mag. J. [3] 6. 421. Pogg. Ann. 38. 123. J. pr. Chem. 5. 90. Gmelin-Kraut 3. 339. Ros. and Sch. 2. 2. 95. (7) Gmelin-Kraut 3. 236. Ros. and Sch. 2. 1. 288. (8) Ros. and Sch. 2. 1. 288. (9) Gmelin-Kraut 3. 236. (10) Ann. Chim. Phys. 20. 275. Gmelin-Kraut. 3. 235. (11) Compt. rend. 44. 1159. Ann. Chim. Phys. [4] 12. 426. Instit. 1867. 185. Bull. Soc. Chim. [2] 8. 259. J. Ph. Chim. [4] 7. 112. J. pr. Chem. 102. 90. Zeitschr. Anal. Chem. 7. 244. Jahresb. 20. 151. Gmelin-Kraut 3. 235. Watts Dict. Sup. 1. 1072.

\* (1) J. pr. Chem. 62. 381. Jahresb. 7. 361. Gmelin-Kraut 3. 235. (2) J. pr. Chem. 31. 397. (3) Ros. and Sch. 2. 1. 244. (4) Scheik. Verh. 1864. 53. Gmelin-Kraut 2. 1. 459. (5) Miller 453. (6) Phil. Mag. J. [3] 6. 421. Trans. Roy. Soc. Ed. 13. 297. J. pr. Chem. 5. 90. Pogg. Ann. 38. 123. Gmelin-Kraut 2. 1. 455. (7) Watts Dict. 5. 600. Ros. and Sch. 2. 1. 244. Miller 453. (8) Chem. Soc. J. 37. 106. (9) Ber. 4. 471. Gmelin-Kraut 2. 1. 459.

Anhydrous magnesium sulphate withstands a moderate red heat without decomposition, but when subjected to a three hours heating at strong redness, it loses  $\frac{1}{2}$  its acid ; and after longer heating the insoluble residue, when treated with acids, evolves hydrosulphuric acid gas, Daubeny (1).\*

When the anhydrous salt is subjected to a white heat over a Bunsen-gas-bellows in an open or covered crucible, or to the melting heat of iron in Schlösing's apparatus, it loses the whole of its acid, and leaves a residue of magnesia, Boussingault (2). Small quantities of the sulphate are always decomposed at a cherry red heat under the formation of magnesia, Gay-Lussac (4).

*Manganic Sulphate.*  $Mn_2(SO_4)_3$ .

Manganic sulphate can be heated to  $160^\circ$  with loss of oxygen or acid ; but at a red heat it loses oxygen and sulphuric anhydride, and is converted into manganous sulphate, Carius (3).

*Manganous Sulphate.*  $MnSO_4 \cdot 7H_2O$ .

Manganous sulphate with 7 mol. of water of crystallization loses 4.9 per cent. of its water when heated between  $9$  and  $11^\circ$  ; 18.6 per cent. between  $12.5$  and  $15^\circ$  and at  $19^\circ$  it melts under the separation of a salt containing 2 mol. of water, Brandes (1).† The salt with 5 mol. of water ( $MnSO_4 \cdot 5H_2O$ ) loses 4 mol. at  $100^\circ$ , T. E. Thorpe and J. I. Watts (2), or at  $210^\circ$ , T. Graham (3), 29.87 per cent. at  $150^\circ$ , Petterson (4), and becomes anhydrous at  $200^\circ$ , T. Graham (5), at  $280^\circ$ , T. E. Thorpe and J. I. Watts (6), or at a red heat (7).

The salt with 4 mol. of water ( $MnSO_4 \cdot 4H_2O$ ), when heated, decomposes without melting and forms a white powder, Brandes (8). Anhydrous manganous sulphate withstands an incipient red heat without decomposition ; but at a stronger redness it evolves oxygen,

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\* (1) Ed. Phil. J. 7. 111. Gmelin-Kraut 2. 1. 455. (2) Compt. Rend. 64. 1159. Ann. Chim. Phys. [4] 12. 419. Bull. Soc. Chim. [2] 8. 259. Instit. 1867. 185. J. pr. Chem. 102. 90. Zeitschr. Anal. Chem. 7. 244. Jahresb. 20. 151. Gmelin-Kraut 2. 1. 287. (3) Ann. Chim. Phys. [2] 13. 310. [4] 12. 419. (4) Annalen 98. 60. Gmelin-Kraut 2. 2. 489.

† (1) Pogg. Ann. 20. 556. Gmelin-Kraut 2. 2. 487. (2) Chem. Soc. J. 37. 113. (3) Phil. Mag. J. [3] 6. 420. Trans. Roy. Soc. Ed. 13. 297. J. pr. Chem. 5. 90. Pogg. Ann. 38. 123. (4) Nova Acta R. Soc. Scient. 1879. (5) Ros. and Sch. 2. 2. 8. (6) Chem. Soc. J. 37. 113. Gmelin-Kraut 2. 2. 485. (7) Gmelin-Kraut

sulphurous anhydride and sulphuric anhydride, and leaves manganoso-manganic oxide (9).

*Mercuric Sulphate.*  $HgSO_4$ .

Mercuric sulphate, when gently warmed, becomes yellow and afterwards of a reddish color, and decomposes when strongly heated into mercury, sulphurous anhydride, mercurous sulphate and oxygen, Mohr (10).

*Mercurous Sulphate.*  $Hg_2SO_4$ .

Mercurous sulphate melts at a dull red heat, Gay-Lussac (1), to a deep red-brown liquid, which on cooling forms a crystalline mass, Städelér (2).

The salt evolves immediately on melting a mixture of 103 parts of sulphurous anhydride and 97 parts of oxygen, while metallic mercury with a little sulphate and a very little sulphuric acid goes over undecomposed, Gay-Lussac (1).<sup>\*</sup> Mercurous sulphate, when strongly heated, sublimes under partial decomposition to metallic mercury and mercuric sulphate, Städelér (3).

*Nickelous Sulphate.*— $NiSO_4 \cdot 7H_2O$ .

Nickelous sulphate with 7 mol. of water loses at 100° about 4 mol., Carl von Hauer (4), or 6 mol., T. E. Thorpe and J. I. Watts (5) and at 103.3° 6 mol., T. Graham (6), becoming anhydrous at 250°, T. E. Thorpe and J. I. Watts (7), or at 279.4°, Graham (8). The salt with 6 mol. of water when heated to 200–250°, becomes greenish-yellow, and gradually loses all its water (1); † at a higher temperature sulphuric acid is expelled; but it is difficult to drive off the last traces of acid even at an incipient white heat, Pierre (2).

2. 2. 485. (8) Pogg. Ann. 20. 556. Gmelin-Kraut 2. 2. 486. (9) Gmelin-Kraut 2. 2. 485. (10) Gmelin-Kraut 3. 763. Ros. and Sch. 2. 1. 407.

<sup>\*</sup> (1) N. Gehl. 4. 469. Gmelin-Kraut 3. 762. (2) Annalen 87. 129. Pharm. Centr. 1853. 785. J. pr. Chem. 61. 471. Jahresb. 6. 387. Gmelin-Kraut 3. 762. Ros. and Sch. 2. 1. 401. (3) Annalen 87. 129. Pharm. Centr. 1853. 785. J. pr. Chem. 61. 471. Jahresb. 6. 387. (4) Wien. Akad. Ber. 39. 305. Gmelin-Kraut 3. 549. (5) Chem. Soc. J. 37. 110. Ros. and Sch. 2. 2. 151. (6) Gmelin-Kraut 3. 549. (7) Chem. Soc. J. 37. 110. (8) Gmelin-Kraut 3. 549. Ros. and Sch. 2. 2. 151.

† (1) Ann. Chim. Phys. [3] 16. 252. Gmelin-Kraut 3. 550. (2) Ann. Chim.

The anhydrous salt, when heated to a gentle redness, leaves, without melting, but with loss of acid, a basic salt, and at a red heat loses almost all its acid (3).

*Potassium Sulphate.*  $K_2SO_4$ .

Potassium sulphate, when heated, decrepitates strongly (4), and melts at a bright red heat (5), or at a cherry red heat, Jacquelin (6). When a small quantity of the sulphate is subjected to a white heat, either in an open or covered crucible, it loses in weight, leaving an alkaline residue, Alexander Mitscherlich (7).

When the salt is heated in an open crucible over a Bunsen-gas-bellows at a temperature at which silicates are decomposed, it loses in weight and leaves an alkaline residue; but when heated in Schlösing's apparatus at the temperature of melting iron, it loses  $\frac{1}{3}$  of its original weight in 20 minutes, and in 30 minutes is entirely volatilized, Boussingault (1).\*

*Silver Sulphate.*  $Na_2SO_4$ .

Silver sulphate decrepitates at  $300^\circ$  (2), melts at  $654^\circ$ , Thomas Carnelley (3), or at a dark red heat, and at a very high temperature is reduced with the evolution of sulphurous anhydride and oxygen, to metallic silver (4).

*Sodium Sulphate.*  $Na_2SO_4$ .

Sodium sulphate melts at  $861^\circ$ , Thomas Carnelley (3), or at  $1280^\circ$ , Braun (5), and at a strong red heat becomes a clear liquid, which on cooling forms a transparent laminated mass, Karsten (6). When the salt is heated in an open or covered crucible for 5 minutes at a white heat it loses in weight and leaves a residue only slightly alkaline in reaction, Alexander Mitscherlich (7).

Sodium sulphate at a white heat in Schlösing's apparatus vapor-

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Phys. [3] 16, 252. (3) Gmelin-Kraut 3. 548. (4) Miller 338. (5) Watts Dict. 5. 607. (6) Ann. Chim. Phys. 70. 319. (7) J. pr. Chem. 82. 485. Zeitschr. Anal. Chem. 1. 63.

\* (1) Compt. rend. 64. 1159. Ann. Chem. Phys. [4] 12. 427. Instit. 1867. 185. Bull. Soc. Chim. [2] 8. 259. J. pr. Chem. 102. 90. Zeitschr. Anal. Chem. 7. 244. J. Ph. Chim. [4] 7. 112. Jahresb. 20. 151. Gmelin-Kraut 2. 1. 43. (2) Gmelin-Kraut 3. 926. (3) Chem. Soc. J. 33. 273. (4) Gmelin-Kraut 3. 926. Watts Dict. 5. 609. Ros. and Sch. 2. 1. 376. (5) Pogg. Ann. 154. 190. (6) Gmelin-Kraut 2. 1. 182. (7) J. pr. Chem. 83. 485. Zeitschr. Anal. Chem. 1. 63.



izes, boiling at the melting heat of iron ; and by incomplete volatilization the residue has a sharp alkaline reaction, Boussingault (1).\*

*Stannous Sulphate.  $\text{SnSO}_4$ .*

Stannous sulphate decomposes at a red heat and leaves stannic oxide, Gay-Lussac (2), Bouquet (3).

*Strontium Sulphate.  $\text{SrSO}_4$ .*

Strontium sulphate melts at a violent heat to a glassy mass (4). When the salt is subjected to the temperature of melting iron in Schlösing's apparatus, it not only loses all its acid, but also some of the strontia formed is volatilized, Boussingault (5). Sulphate of strontia loses sulphuric acid when strongly ignited, Darmstadt (6), and leaves the pure oxide behind, Darmstadt (7).

*Zinc Sulphate.  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ .*

Crystallized zinc sulphate melts when heated (8), loses 6 mol. of its water at  $100^\circ$ , T. Graham (9), Kühn (10), Van Der Zoon (11), or at  $100$ – $110^\circ$ , T. E. Thorpe and J. I. Watts (1),† becomes anhydrous at a temperature above  $110^\circ$ , Van Der Zoon (2), at  $238^\circ$ , T. Graham, (3), at about  $260^\circ$ , (4), at  $280$ – $300^\circ$ , T. E. Thorpe and J. I. Watts (1), at a moderate red heat (5), or at  $118^\circ$  in a stream of hot air, Pierre (6). The anhydrous salt at the fusing heat of silver decomposes into sulphurous anhydride and oxygen, leaving a residue, which consists of 99.3 per cent. of zinc oxide and 7 per cent. of zinc sulphate, H. Deville and H. Debray (7), and at a bright red heat

\*(1.) Compt. rend. 64. 1159. Ann. Chim. Phys. [4] 12. 427. Instit. 1867. 185. Bull. Soc. Chim. [2] 8. 259. J. pr. Chem. 102. 90. Zeitschr. Anal. Chem. 7. 244. Jahresb. 20. 151. Gmelin-Kraut 2. 1. 182. (2) Gmelin-Kraut 3. 119. (3) J. Ph. Chim. [3] 11. 459. Annalen 64. 278. Jahresb. 1. 436. Gmelin-Kraut 3. 119. (4) Gmelin-Kraut 2. 1. 329. (5) Compt. rend. 64. 1159. Ann. Chim. Phys. [4] 12. 427. Instit. 1867. 185. Bull. Soc. Chim. [2] 8. 259. J. pr. Chem. 102. 90. Zeitschr. Anal. Chem. 7. 244. Jahresb. 20. 151. Gmelin-Kraut 2. 1. 329. (6) Bull. Soc. Chim. 1869. No. 2. Chem. News 19. 322. (7) Zeitschr. Anal. Chem. 6. 376. Jahresb. 20. 152. (8) Ros. and Sch. 2. 1. 262. Miller 467. (9) Phil. Mag. J. [3] 6. 33. Trans. Roy. Soc. Ed. 13. 297. J. pr. Chem. 5. 90. Pogg. Ann. 38. 123. Gmelin-Kraut 3. 24. Watts Dict. 5. 617. (10) Gmelin-Kraut 3. 24. (11) Berzelius' Jahresb. 15. 179. Gmelin-Kraut 3. 24.

† (1) Chem. Soc. J. 37. 108. (2) Berzelius' Jahresb. 15. 179. Gmelin-Kraut 3. 23. (3) Phil. Mag. J. [3] 6. 33. Trans. Roy. Soc. Ed. 13. 297. J. pr. Chem. 5. 90. Pogg. Ann. 38. 123. Gmelin-Kraut 3. 23. (4) Watts Dict. 5. 617. (5) Gmelin-Kraut 3. 24. Ros. and Sch. 2. 1. 262. (6) Ann. Chim. Phys. [3] 16. 241. (7)

(8), or at a white heat (9), it is entirely decomposed, leaving a residue of zinc oxide (10). When a crystal of the prismatic form is heated to over  $52^{\circ}$ , it soon changes into an aggregation of small crystals of the same composition, Wilhelm Haidinger (11), or else containing only 6 mol. of water, Mitscherlich (12).

## THE SULPHIDES.

### *Aluminium Sulphide.* $Al_2S_3$ .

Aluminium sulphide is difficultly fusible, forming thereby a hard crystalline mass. When it is heated in the air it burns, sulphurous anhydride being evolved and the oxide left as a residue, Friedrich Gustav Reichel (1):\*

### *Ammonium Sulphide.* $(NH_4)_2S$ .

Ammonium sulphide even at an ordinary temperature is at once decomposed, losing ammonia and being converted into the hydrosulphide (2).

### *Antimonous Sulphide.* $Sb_2S_3$ .

Antimonous sulphide is easily fusible (3) and melts below a red heat (4). When roasted in the open air it burns, yielding sulphurous anhydride, antimonous and antimonious oxide (5); or is converted into a mixture of the oxide and sulphide of antimony (4); but at a high temperature it produces sulphurous anhydride and antimonous oxide (6). It boils at a strong red heat (3), and can be distilled unchanged in closed vessels (7). The red crystalline sulphide of antimony, when heated at  $180^{\circ}$ , becomes dark, but recovers its original color again on cooling; while at  $200^{\circ}$  it is converted into the black modification, H. Rose (8). When the crystalline salt is kept in a state of fusion for some time and then thrown into cold water, it becomes amorphous and on the other hand the amorphous,

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Ann. Chim. Phys. [3] 61. 123. Compt. rend. 51. 822. Instit. 1860. 387. Dingl. pol. J. 159. 50. Annalen 117. 295. Zeitschr. Chem. Pharm. 1861. 19. Jahresb. 14. 53. Gmelin-Kraut 3. 18. (8) Watts Dict. 5. 617. (9) Ros. and Sch. 2. 1. 262. (10) Watts Dict. 5. 617. Ros. and Sch. 2. 1. 262. (11) Pogg. Ann. 11. 176. (12) Gmelin-Kraut 3. 24.

\* (1) J. pr. Chem. 120. 55. Amer. Chemist. 6. 233. (2) Watts Dict. 1. 194. (3) Gmelin Watts Transl. 4. 337. (4) Miller 599. (5) Gmelin Watts Transl. 4. 338. Watts Dict. 1. 332. (6) Gmelin Watts Transl. 4. 338. (7) Gmelin Watts Transl. 4. 338. Miller 599. (8) Pogg. Ann. 89. 122. Annalen 88. 257.

when melted and allowed to cool slowly, becomes crystalline, Joh. Nep. Fuchs (1).\*

*Antimonic Sulphide. Sb<sub>2</sub>S<sub>3</sub>.*

Antimonic sulphide, when heated in a closed vessel to the boiling point of sulphur is resolved into the tri-sulphide and free sulphur, A. Mitscherlich (2). It swells up in the fire and burns with a flame, A. Vogel (3).

*Arsenic Sulphide. As<sub>2</sub>S<sub>3</sub>.*

Arsenic sulphide is fusible and can be sublimed without decomposition when the air is excluded (4).

*Arsenious Sulphide. As<sub>2</sub>S<sub>2</sub>.*

Arsenious sulphide is easily fusible, and if access of air be prevented it volatilizes undecomposed (5); it boils at about 700°, A. Mitscherlich (6). The salt when heated in the air burns and sulphurous anhydride is evolved, Charles W. Vincent (7), together with the trioxide of arsenic (8).

*Barium Sulphide. BaS.*

The anhydrous barium sulphide remains almost unchanged, when roasted, Berthier (1).† Barium sulphide with 6 mol. of water (BaS·6H<sub>2</sub>O), when heated between 100° and 350°, loses its water of crystallization together with some hydro-sulphuric acid; at a higher temperature it evolves hydro-sulphuric acid and sulphur, leaving a residue, which consists of the sulphide and sulphate of barium with traces of sulphite, Schöne (2).

*Bismuth Sulphide. Bi<sub>2</sub>S<sub>3</sub>.*

When the tri-sulphide of bismuth is heated in closed vessels, it is decomposed into a sub-sulphide and free sulphur, which distills (3); in the open air sulphurous anhydride escapes and bismuthic oxide remains (4). At each successive fusion of the artificial sulphide

\* (1) Pogg. Ann. 31. 578. Gmelin. Watts Transl. 4. 340. (2) Gmelin. Watts Transl. 4. 357. Watts Dict. 1. 334. Ros. and Sch. 2. 2. 323. (3) Gmelin. Watts Transl. 4. 357. (4) Ros. and Sch. 1. 533. Miller 585. (5) Gmelin. Watts Transl. 4. 273. Ros. and Sch. 1. 532. Miller 584. (6) Gmelin. Watts Transl. 4. 273. Ros. and Sch. 1. 532. (7) Phil. Mag. J. [4] 14. 127. (8) Ros. and Sch. 1. 532.

† (1) Ann. Chim. Phys. 22. 231. Gmelin-Kraut. 2. 1. 277. (2) Pogg. Ann. 112. 193. Zeitschr. Chem. Pharm. 1861. 429. Rep. Chim. pure. 3. 468. Jahresb. 14. 122. Gmelin-Kraut 2. 1. 273. (3) Gmelin. Watts Transl. 4. 435.

globules of metallic bismuth separate from the solidifying mass, Marx (5).

*Cadmium Sulphide. CdS.*

Cadmium sulphide melts at an incipient red heat and is non-volatile at any temperature, Stromeyer (6).

The salt on being heated assumes at first a brown color and afterwards a crimson, which it loses on cooling, Stromeyer (1).<sup>\*</sup> When cadmium sulphide is heated over 100° in stream of air its color grows a darker red as the temperature rises; and at no temperature does it decompose or volatilize; while, however, it oxidizes on the surface when the heat is continued for a long time at over 135–140°, O. Follenius (2).

*Calcium Sulphide. CaS.*

Calcium sulphide cannot be melted at a white heat, and is almost unchanged by roasting, Berthier (3).

*Chromium Sulphide.*

Chromium sulphide when strongly heated in the air burns, evolving sulphurous anhydride and leaving the green oxide behind, J. L. Lassaigne (4), H. Moissan (5), Traube (6), Schafrik (6), or a green basic sulphate, W. Müller (7); but when heated in a closed vessel a portion of the sulphur is driven off in a free state, H. Moissan (5).

*Cupric Sulphide. CuS.*

Cupric sulphide when heated to redness with the exclusion of the air changes into cuprous sulphide,  $\frac{1}{2}$  of its sulphur volatilizing, Dobereiner (1),<sup>†</sup> Spencer Pickering (2).

Miller 605. (5) Schw. 58. 472. 59. 114. Gmelin. Watts Transl. 4. 435. (6) Ann. Chim. Phys. 11. 82. Gmelin-Kraut 3. 66, 67. Watts Dict. 1. 706. Ros. and Sch. 2. 1. 268. Miller 469.

<sup>\*</sup>(1) Ann. Chim. Phys. 11. 82. (2) Zeitschr. Anal. Chem. 13. 421. (3) Ann. Chim. Phys. 22. 238. Gmelin-Kraut 2. 1. 377. (4) Ann. Chim. Phys. 14. 300. Gmelin-Kraut 2. 2. 305. Ros. and Sch. 2. 2. 180. (5) Compt. rend. 90. 817. Chem. Soc. J. 38. 527. (6) Gmelin-Kraut 2. 2. 305. (7) Pogg. Ann. 127. 404. Chem. Centr. 1866. 561. Zeitschr. Chem. 1866. 257. Bull. Soc. Chim. [2] 6. 441. Jahresb. 19. 120. Gmelin-Kraut 2. 2. 305.

<sup>†</sup>(1) Schw. 17. 414. Gmelin-Kraut 3. 619. Ros. and Sch. 2. 1. 843. Chem.

When subjected to heat in the air it acts like cuprous sulphide (3).

*Cuprous Sulphide.  $Cu_2S$ .*

Cuprous sulphide is easily fusible in a closed vessel (4), and when heated out of contact with air decomposes into metallic copper and cupric sulphide, Hittorff (5); while according to others it does not change (6). When it is subjected to heat in the open air, combustion takes place and sulphurous anhydride and free cupric oxide are formed (7); or in addition some cupric sulphate (8).

*Ferric Sulphide.  $Fe_2S_3$ .*

Ferric sulphide when subjected to a strong red heat is converted, under loss of sulphur, into the di-sulphide, Berzelius (9), or into ferrous sulphide, Rammelsberg (9).

*Ferrous Sulphide.  $FeS$ .*

Ferrous sulphide at a gentle heat in the air is partially converted into ferrous sulphate, while at a stronger heat sulphurous anhydride is evolved and ferric oxide remains (1).\*

It does not lose sulphur when heated to whiteness in absence of air, Berthier (2).

*Lead Sulphide.  $PbS$ .*

Sulphide of lead melts at a strong red heat, vaporizes at a stronger heat, and sublimes unchanged if the air be excluded, Rodwell (3). When gently heated in the air sulphurous anhydride is evolved, while metallic lead and lead sulphate remain behind, Descotils (4). If the sulphide be heated at  $125-150^\circ$  until sulphurous anhydride begins to appear and then the heat discontinued, a sulphite is formed and not a sulphate as is usually supposed, F. Rodwell (5).

*Magnesium Sulphide.  $MgS$ .*

Magnesium sulphide is quite infusible at the usual temperature

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Soc. J. 39. 406. (3) Miller 619. (4) Miller 618. (5) Pogg. Ann. 84. 1. Gmelin-Kraut 3. 617. (6) Gmelin-Kraut 3. 617. (7) Watts Dict. 2. 74. (8) Gmelin-Kraut 3. 617. Miller 619. (9) Gmelin-Kraut 3. 333.

\*(1) Gmelin-Kraut 3. 329. Watts Dict. 3. 400. Ros. and Sch. 2. 2. 118. (2) Gmelin-Kraut 3. 330. Ros. and Sch. 2. 2. 118. (3) Gmelin-Kraut 3. 232. (4) Ann. Chim. Phys. 55. 441. Gmelin-Kraut 3. 230. Watts Dict. 3. 558. (5)

of furnaces, Friedrich Gustav Reichel (6) ; but burns in the air. F. G. Reichel (7).

*Manganous Sulphide.  $MnS$ .*

Manganous sulphide is not changed by strong heating in a closed tube, Clermont and Guiot (8) ; but when heated in the air it easily gives off all its sulphur as sulphurous anhydride and leaves manganoso-manganic oxide, Arfoedson (1).\*

Manganous sulphide with 1 mol. of water ( $MnS \cdot H_2O$ ) is not changed by being heated in a closed tube at  $300^\circ$ , Clermont and Guiot (2) ; but when it is heated to redness in a retort it is decomposed into water and the anhydrous salt, Berzelius (3), while in the air it evolves sulphurous anhydride and forms manganous sulphate and manganic oxide, Clermont and Guiot (4).

*Mercuric Sulphide.  $HgS$ .*

Mercuric sulphide when heated in the air burns with the formation of sulphur di-oxide and metallic mercury (5).

Cinnabar or vermilion becomes brownish when gently heated, quite brown at  $250^\circ$  and black at a higher temperature, but on cooling again assumes its scarlet-red color, Fickentscher (6). When moderately heated out of contact with the air the amorphous sulphide is formed, while at a stronger heat the red is again produced, Sequin (7). When powdered vermilion is heated in a small glass retort over a spirit lamp until a portion sublimes and then thrown into cold water it is converted into the black sulphide, Joh. Nep. Fuchs (1).† Cinnabar sublimes before undergoing fusion and forms a yellowish-brown vapor (2).

The black or amorphous sulphide is changed by sublimation into the red, Joh. Nep. Fuchs (3).

*Mercurous Sulphide.  $Hg_2S$ .*

Mercurous sulphide at a gentle heat is resolved into a mixture of

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Chem. Soc. J. 16. 46. Gmelin-Kraut 3. 230. (6) J. pr. Chem. 120. 55. Amer. Chem. 6. 233. Ros. and Sch. 2. 1. 248. (7) J. pr. Chem. 120. 55. Amer. Chem. 6. 233. (8) Gmelin-Kraut 2. 2. 282.

\* (1) Gmelin-Kraut 2. 2. 478. Watts Dict. 3. 817. (2) Ann. Chim. Phys. [5] 12. 111. Compt. rend. 84. 653. Bull. Soc. Chim. [2] 27. 353. Jahresb. 30. 256. Gmelin-Kraut 2. 2. 478. (3) Gmelin-Kraut 2. 2. 478. (4) Compt. rend. 85. 78. Gmelin-Kraut 2. 2. 480. (5) Gmelin-Kraut 3. 758. Watts Dict. 3. 912. Miller 654. (6) Gmelin-Kraut 3. 758. Watts Dict. 3. 912. (7) Ann. Chim. 90. 268. Gmelin-Kraut 3. 759.

† (1) Pogg. Ann. 31. 581. (2) Miller 652. (3) Pogg. Ann. 31. 581. Gmelin-

mercuric sulphide and metallic mercury (4). At a stronger heat it yields a sublimate first of metallic mercury and afterwards of cinnabar (5).

*Potassium Sulphide.  $K_2S$ .*

Potassium sulphide burns very slowly in the air when heated to redness, since a film of sulphate is formed on the surface, Berthier (6), Bergelius (7).

The red sulphide becomes darker in the heat and melts below redness to a dark opaque fluid, Berzelius (8).

The flesh-colored sulphide will vaporize at a red heat, Berthier (6).

*Silver Sulphide.  $Ag_2S$ .*

Silver Sulphide is easily fusible and if heated in a closed vessel may be melted without becoming decomposed (1);\* but if heated in the air it is converted into sulphurous anhydride and metallic silver, while at a gentle roasting there is also formed some sulphate of silver, Larranaga (2).

*Sodium Sulphide.  $Na_2S$ .*

Sodium sulphide becomes yellow by melting (3). If it has turned yellow by exposure to air it will by heating become white again, J. Kolb (4).

*Stannic Sulphide.  $SnS_4$ .*

Stannic sulphide, when ignited in a closed vessel, is resolved into sulphur and stannous sulphide, a portion, however, subliming unchanged (5); but when heated in contact with the air, it yields sulphurous anhydride and stannic oxide, Gay-Lussac (6), Berzelius (6).

*Zinc Sulphide.  $ZnS$ .*

Zinc sulphide does not fuse when heated (7) or only at a very high temperature, Deville and Troost (8). It does not vaporize at

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Kraut 3. 756, 760. Watts Dict. 3. 912. Miller 654. (4) Watts Dict. 3. 912. (5) Watts Dict. 3. 912. Miller 653. (6) Ann. Chim. Phys. 22. 233. Gmelin-Kraut 2. 1. 83. (7) Gmelin-Kraut 2. 1. 33. (8) Gmelin-Kraut 2. 1. 33. Ros. and Sch. 2. 1. 97.

\*(1) Miller 682. (2) Gilb. Ann. 22. 304. Gmelin-Kraut 3. 922. Miller 682. (3) Gmelin-Kraut 2. 1. 174. (4) Ann. Chim. Phys. [4] 10. 106. Gmelin-Kraut 2. 1. 174. (5) Gmelin-Kraut 3. 116. Watts Dict. 5. 822. Ros. and Sch. 2. 2. 252. (6) Gmelin-Kraut 3. 117. Watts Dict. 5. 822. (7) Miller 466. (8) Compt.

a white heat, Deville and Troost (8), but does at the very highest temperature attainable, Sidot (9).

When the salt is heated in the air it oxidizes slowly, sulphurous anhydride being evolved, and the oxide and sulphate of zinc left behind (10). At a low temperature some sulphate is formed, but at a high heat only the oxide is left (11).

### THE SULPHITES.

#### *Aluminium Sulphite.* $Al_2(SO_3) \cdot 4H_2O$ .

Aluminium sulphite when exposed to a temperature of  $100^\circ$  gives off sulphurous anhydride, Gougginberg (1),\* and when heated, uninterruptedly for a long time at a strong redness loses all its acid and leaves behind pure aluminium oxide, Gougginberg (2), J. S. Muspratt (3); but when heated for only a short time the residue is found to contain some sulphate, Foucroy and Vanquelin (4).

#### *Ammonium Sulphite.* $(NH_4)_2SO_3$ .

Ammonium sulphite, when heated, decrepitates slightly, becomes soft without fusing (5), loses water and afterwards a large amount of ammonia, and at a higher temperature sublimes in the form of a silky mass, J. S. Muspratt (6).

#### *Barium Sulphite.* $BaSO_3$ .

Barium sulphite at a gentle heat decrepitates and at a higher temperature evolves water, sulphurous anhydride and sulphur, J. S. Muspratt (7). When it is heated to redness in a closed vessel, it is resolved into a mixture of the sulphide and sulphate of Barium,  $4BaSO_3 = BaS + 3BaSO_4$ , C. Rammelsberg (8), Forester (9).

#### *Bismuth Sulphite.* $Bi_2(SO_3)_3$ .

Bismuth sulphite loses nearly its whole acid in the heat, J. S. Muspratt (1).†

#### *Cadmium Sulphite.* $CdSO_3$ .

Cadmium sulphite gives off sulphurous oxide in the heat, and leaves a yellow residue consisting of oxide, sulphite and sulphate of cadmium, C. Rammelsberg (2).

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rend. 52. 920. Gmelin-Kraut 3. 18. (9) Compt. rend. 63. 188. Gmelin-Kraut 3. 18. (10) Gmelin-Kraut 3. 18. (3) Miller 466.

\* (1) Annalen 45. 132. Gmelin-Kraut 2. 1. 635. (2) Annalen 45. 132. Gmelin-Kraut 2. 1. 635. Chem. Gaz. 1. 367. (3) Annalen 50. 277. (4) Gmelin-Kraut 2. 1. 635. (5) Gmelin. Watts Trans. 2. 457. (6) Annalen 50. 259. Watts Dict. 5. 542. (7) Annalen 50. 273. Gmelin-Kraut 2. 1. 284. (8) Pogg. Ann. 67. 248. Watts Dict. 5. 543. (9) Pogg. Ann. 133. 239. Jahresb. 21. 197. Gmelin-Kraut 2. 1. 284.

† (1) Annalen 50. 286. (2) Pogg. Ann. 67. 256. Gmelin-Kraut 3. 67. Watts



*Calcium Sulphite.*  $\text{CaSO}_3 \cdot 2\text{H}_2\text{O}$ .

Calcium sulphite, when heated, gives off water, sulphurous oxide, and sulphur, and leaves a residue consisting of the sulphide and sulphate of calcium, J. S. Muspratt (3); but when subjected to a dull red heat with the exclusion of the air, it leaves behind without forming any volatile products, a mixture of the sulphide and sulphate of calcium, C. Rammelsberg (4), Forester (5).

When the anhydrous sulphate of calcium is heated above redness, sulphurous anhydride is evolved and a mixture of the sulphide, sulphate and sulphite is left, Fr. Schott (6).

*Chromium Sulphite.*

Chromium sulphite gives off a large amount of sulphurous anhydride when heated, J. S. Muspratt (1).\*

*Cuprous Sulphite.*  $\text{Cu}_2\text{SO}_3 \cdot \text{H}_2\text{O}$ .

Cuprous sulphite is decomposed when it is heated in a crucible, sulphurous anhydride and sulphur being evolved and a residue of cupric sulphate and sulphide left behind, J. S. Muspratt (2). For basic cupric sulphite see (3).

*Ferrous Sulphite.*

Ferrous sulphite when heated in the air gives off water first, and then at a temperature of about  $250^\circ$  sulphurous anhydride, leaving a residue consisting of a mixture of ferric, and a variable amount of ferrous oxide, Dr. Koene (4).

*Lead Sulphite.*  $\text{PbSO}_3$ .

Sulphite of lead gives off sulphurous anhydride in the heat, and leaves a mixture of the sulphate and sulphide of lead (5), together with some lead oxide,  $5\text{PbSO}_3 = \text{SO}_2 + 3\text{PbSO}_4 + \text{PbS} + \text{PbO}$ , J. S. Muspratt (6).

*Magnesium Sulphite.*  $\text{MgSO}_3 \cdot 6\text{H}_2\text{O}$ .

Magnesium sulphite loses some water of crystallization at  $100^\circ$ ,

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Dict. 5. 543. (3) Annalen 50. 274. Watts Dict. 5. 543. (4) Pogg. Ann. 67. 249. (5) Pogg. Ann. 133. 106. Jahresb. 21. 197. Gmelin-Kraut 2. 1. 382. (6) Dingl. 202. 52. Tech. Jahr. 1871. 504. Gmelin-Kraut 2. 1. 382.

\* (1) Annalen 50. 289. Watts Dict. 5. 543. (2) Annalen 50. 284. (3) Pogg. Ann. 67. 399. (4) Pogg. Ann. 63. 444. (5) Gmelin-Kraut 3. 234. Watts Dict. 5. 546. Miller 639. (6) Annalen 50. 284.

but the whole is not expelled until the temperature of  $200^{\circ}$  is reached, at which point it decomposes with a loss of sulphurous anhydride, C. Rammelsberg (1),\* while at a more elevated temperature the salt loses sulphur, air being excluded, swells up, becomes yellow, then brown, and on cooling settles together in the form of a white mass, consisting of the oxide and sulphate of magnesium, C. Rammelsberg (2),  $4\text{MgSO}_4 = \text{SO}_2 + \text{S} + 2\text{MgO} + 2\text{MgSO}_3$ , J. S. Muspratt (3).

*Manganous Sulphite.*  $\text{MnSO}_3 \cdot 2\text{H}_2\text{O}$ .

Manganous sulphite loses its water at  $100^{\circ}$ , and when strongly heated in the air evolves sulphurous anhydride and leaves a dark brown residue, consisting for the most part of manganic oxide, J. S. Muspratt (4); but when it is heated in a retort, it gives off water and sulphurous oxide, grows darker in color and if the temperature be raised to redness, it leaves a greenish-brown pulverulent residue of manganic oxide, manganous sulphate and sulphide of manganese, C. Rammelsberg (5).

*Mercurous Sulphite.*  $2\text{Hg}_2\text{O} \cdot 3\text{SO}_3$ .

Mercurous sulphite, when heated in a close tube, melts to a reddish-brown liquid, evolves sulphurous anhydride and yields a sulphinate of metallic mercury and mercuric sulphate, C. Rammelsberg (1).†

*Nickelous Sulphite.*  $\text{NiSO}_3 \cdot 4\text{H}_2\text{O}$  or  $6\text{H}_2\text{O}$ .

Nickelous sulphite, when heated in a small retort, melts with the separation of water, becomes darker and compact, gives off sulphurous anhydride, and leaves a gray-green residue of sulphate, oxide and sulphide of nickel, the latter being in excess, C. Rammelsberg (2); but when put into a crucible and heated, it leaves a voluminous residue, which consists for the most part of nickelous oxide, J. S. Muspratt (3), amounting to 30.48 per cent., Fordos and Gelis (4).

*Potassium Sulphite.*  $\text{K}_2\text{SO}_3 \cdot 2\text{H}_2\text{O}$ .

Potassium sulphite, when heated, swells up, and at an elevated temperature gives off sulphurous anhydride, and leaves a residue, consisting mostly of the sulphate of potassium, which is mixed with

\* (1) Pogg. Ann. 67. 250. Watts Dict. 5. 546. (2) Pogg. Ann. 67. 250. (3) Annalen 50. 275. (4) Annalen 50. 280. Gmelin-Kraut 2. 2. 483. (5) Pogg. Ann. 67. 256. Gmelin-Kraut 2. 2. 483. Watts Dict. 5. 547.

† (1) Pogg. Ann. 67. 405. Gmelin-Kraut 3. 760. Watts Dict. 5. 547. (2) Pogg. Ann. 67. 391. Gmelin-Kraut. 3. 547. (3) Annalen 50. 281. (4) J. Ph.

some sulphide and probably some free alkali,  $5K_2SO_3 = SO_2 + 3K_2SO_4 + K_2S + K_2O$ , J. S. Muspratt (5).

*Silver Sulphite.*  $Ag_2SO_3$ .

Silver sulphite, when heated to  $100^\circ$ , decomposes into metallic silver and sulphate of silver, Berthier (1) ;\* but when heated in a crucible to an incipient redness, it evolves sulphurous anhydride and leaves metallic silver together with some sulphate, which at a strong red heat decomposes into metallic silver, oxygen and sulphuric acid, J. S. Muspratt (2).

*Sodium Sulphite.*  $Na_2SO_3 \cdot 7H_2O$ .

Sodium sulphite melts at  $113^\circ$  (3), and at or under  $150^\circ$  it gives off the whole of its water, becoming white and enamel-like, and at a higher temperature it melts to yellowish-red mass, consisting of 1 p't of the sulphide and 3 p'ts of the sulphate of sodium, C. Rammelsberg (4), Vanquelin (5). When the salt is heated it melts in its water of crystallization under strong inflation, and at a higher temperature loses its water and a portion of its acid, J. S. Muspratt (6).

*Strontium Sulphite.*  $SrSO_3$ .

Strontium sulphite, when heated, evolves sulphurous anhydride and sulphur, J. S. Muspratt (7) ; but when subjected to a red heat with exclusion of the air, it leaves a mixture of the sulphide and sulphate of strontium,  $4SrSO_3 = SrS + 3SrSO_4$ , A. Forester (8).

*Zinc Sulphite.*  $ZnSO_3 \cdot 2H_2O$ .

Zinc sulphite, when heated in a glass tube, decomposes above  $200^\circ$ , evolving sulphurous anhydride and leaving behind zinc oxide, Dr. Koene (9) ; but when heated in a closed vessel, it gives off water and sulphurous anhydride, and leaves behind a yellowish-white residue, which consists of the sulphide, sulphate and oxide of zinc, C. Rammelsberg (10), J. S. Muspratt (11).

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Chim. [3] 4. 333. Gmelin-Kraut 3. 547. (5) Annalen 50. 261. Gmelin-Kraut 2. 1. 41. Watts Dict. 5. 549.

\* (1) Ann. Chim. Phys. [8] 7. 82. Gmelin-Kraut 3. 925. Ros. and Sch. 2. 1. 376. (2) Annalen 50. 286. Gmelin-Kraut 3. 925. (3) Miller 361. (4) Pogg. Ann. 67. 247. Gmelin-Kraut 2. 1. 180. Watts Dict. 5. 549. (5) Ann. Chim. 24. 264. Crell. Ann. 2. (1800) 405. (6) Annalen 50. 268. (7) Annalen 50. 274. Gmelin-Kraut 2. 1. 329. (8) Pogg. Ann. 133. 106. Jahresb. 21. 197. Gmelin-Kraut 2. 1. 329. (9) Pogg. Ann. 63. 435. (10) Pogg. Ann. 67. 253. Gmelin-Kraut 3. 21. (11) Annalen 50. 283. Watts Dict. 5. 550.

## INDEX TO AUTHORS.

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- Andrews. Stannic chloride.  
Arvedson. Manganous sulphide,  
Balard. Barium bromide. Magnesium bromide. Mercuric  
bromide. Lead bromide. Potassium bromide. Silver bromide. Stannic bromide.  
Bauch and Wöhler, see Wöhler and Bauch.  
Bergman. Ferric phosphate.  
Bersch. Cobaltous chloride.  
Berthelot. Ammonium nitrate. Ammonium nitrite.  
Berthelot. Aluminium bromide. Antimonous iodide. Cadmium bromide. Chromium bromide. Cobaltous bromide. Cupric bromide. Ferrous bromide. Manganous bromide. Nickelous bromide. Strontium bromide. Zinc bromide.  
Berthier. Barium sulphide. Calcium sulphide. Ferrous sulphide. Lead Sulphate. Potassium sulphide. Silver sulphide.  
Berzelius. Aluminium sulphate. Ammonium nitrate. Barium phosphate. Ferric sulphide. Manganous sulphide. Potassium sulphide. Silver iodide. Silver phosphate. Stannic sulphide.  
Birnbaumk. Calcium phosphate.  
Bley. Lead nitrate.  
Bödeker. Calcium phosphate.  
Bondsdröff. V., Aluminium chloride.  
Boullay. Stannous iodide.  
Bouquet. Stannous Sulphate.  
Boussingault. Barium sulphate. Calcium sulphate. Magnesium sulphate. Lead sulphate. Potassium sulphate. Strontium sulphate.  
Brandes. Antimonous iodide. Lead iodide. Magnesium chloride. Manganous sulphate.  
Braun. Lead chloride. Potassium chloride. Potassium nitrate. Sodium nitrate. Sodium sulphate. Strontium chloride. Zinc chloride.  
Brooke. Strontium nitrate.  
Bucholz. Antimonous sulphate.  
Bunsen. Potassium chloride. Potassium Iodide. Sodium chloride. Sodium iodide.  
Bussy. Antimonous sulphate. Cupric sulphate.  
Capitaine. Antimonous chloride. Stannous chloride.  
Carius and Wanklyn. Ferrous iodide.

- Carnelley. Barium bromide. Barium nitrate. Calcium bromide. Calcium chloride. Calcium iodide. Calcium nitrate. Cuprous iodide. Lead chloride. Lead iodide. Mercuric chloride. Potassium bromide. Potassium chloride. Potassium iodide. Potassium nitrate. Sodium bromide. Sodium chloride. Sodium iodide. Sodium nitrate. Strontium chloride. Strontium iodide
- Carnelley and O'Shea. Stannic bromide.
- Carnelley and Williams. Arsenious iodide. Bismuth bromide. Bismuth chloride. Lead chloride. Mercuric iodide. Stannous bromide. Stannous chloride. Stannous iodide.
- Casselmann. Stannic chloride. Stannous chloride.
- Chodnew. Barium phosphate. Magnesium nitrate.
- Clark. Sodium phosphate.
- Clermont and Guiot. Manganous sulphide.
- Cook. Antimonous bromide. Antimonous chloride. Antimonous iodide.
- Crittenden and Johnson, see Johnson and Crittenden.
- Croft. Barium iodide. Strontium iodide.
- Darmstadt. Strontium sulphate.
- Daubeny. Magnesium sulphate.
- Davy H. Bismuth chloride. Magnesium chloride. Zinc chloride.
- Davy J. Antimonous chloride. Arsenious chloride. Bismuth chloride. Cupric chloride. Cuprous chloride. Ferric chloride. Lead chloride. Stannous chloride. Zinc chloride.
- Debray. Calcium phosphate. Mercuric iodide. Mercurous chloride.
- Debray and Deville, see Deville and Debray.
- Descotils. Lead sulphide.
- Deville. Aluminium nitrate. Ammonium chloride. Ferric nitrate. Mercuric iodide.
- Deville and Debray. Sodium nitrate. Zinc sulphate.
- Deville and Troost. Aluminium bromide. Aluminium iodide. Ferric chloride. Mercurous chloride.
- Dibbitts. Calcium chloride. Magnesium chloride.
- Divers. Silver nitrite.
- Dobereiner. Cupric sulphide. Lead chloride.
- Dritten. Mercuric nitrate.
- Dumas. Arsenious chloride. Barium chloride. Barium iodide. Calcium iodide. Strontium chloride. Strontium iodide.
- Elder and Rodwell, see Rodwell and Elder.
- Elenmeyer. Barium phosphate. Mercurous chloride.
- Elenmeyer and Heinrich. Manganous phosphate.
- Elliot and Storer. Chromium nitrate.
- Erdmann. Lead sulphate. Nickelous chloride. Nickelous iodide.
- Erdmann and Marchland. Lead sulphate.
- Favre and Silbermann. Ammonium nitrate.
- Fellenberg. Cupric chloride.

- Ferdos and Gelis. Nickelous sulphite.  
 Fickentscher. Mercuric sulphide.  
 Fischer. Ammonium nitrite. Barium nitrate. Cadmium nitrite.  
 Calcium nitrate. Cobaltous nitrite. Cupric nitrite. Mag-  
 nesium nitrite. Lead nitrite. Potassium nitrate. Sodium  
 nitrate. Strontium nitrate. Zinc nitrite.  
 Fizeau. Mercuric iodide.  
 Follenius. Cadmium sulphate. Cadmium sulphide.  
 Forester. Barium sulphite. Calcium sulphite. Strontium sul-  
 phite.  
 Foucroy and Vanquelin. Aluminium sulphite.  
 Frankenheim. Ammonium nitrate.  
 Fresenius. Manganous chloride.  
 Fritzsche. Ferric chloride.  
 Gaultier. Chromium chloride.  
 Gay. Mercuric chloride. Mercurous chloride.  
 Gay-Lussac. Ammonium iodide. Antimonic sulphate. Cal-  
 cium iodide. Cupric sulphate. Lead iodide. Mercurous  
 sulphate. Magnesium sulphate. Sodium iodide. Stannic  
 sulphide. Stannous sulphate. Strontium iodide. Zinc iodide.  
 Gay-Lussac and Thenard. Magnesium chloride.  
 Gelis and Ferdos. See Ferdos and Gelis.  
 Gerhardt. Cupric nitrate. Mercurous nitrate. Mercurous phos-  
 phate. Zinc nitrate.  
 Gerlach. Stannic chloride.  
 Girault. Sodium iodide.  
 Gladstone. Bismuth nitrate. Cupric chloride.  
 Gougginsberg. Aluminium sulphite.  
 Graham. Bismuth nitrate. Calcium sulphate. Cupric chloride.  
 Cupric sulphate. Ferrous sulphate. Magnesium sulphate.  
 Manganous sulphate. Nickelous sulphate. Potassium phos-  
 phate. Sodium phosphate. Zinc sulphate.  
 Gregory. Magnesium phosphate.  
 Grouvelle. Zinc nitrate.  
 Guiot and Clermont. See Clermont and Guiot.  
 Gunning. Calcium sulphate.  
 Haagen. Arsenious chloride. Stannic chloride.  
 Hager. Aluminium sulphate.  
 Haidinger. Nickelous sulphate.  
 Hampe. Barium nitrate. Cupric nitrate. Magnesium nitrite.  
 Nickelous nitrite. Strontium nitrate.  
 Hart. Ferric sulphate.  
 Hartley. Cobaltous bromide. Cobaltous iodide.  
 Hauer. v. Cadmium nitrate. Cadmium sulphate. Nickelous  
 sulphate. Sodium sulphate.  
 Hausmann. Ferric nitrate.  
 Hayes. Mercuric iodide.  
 Heintz. Manganous phosphate.  
 Henry, O. Lead iodide. Mercurous bromide.

- Henry, Thomas H. Stannic iodide. Stannous iodide.  
 Herzog. Ammonium iodide.  
 Hess. Barium nitrate.  
 Jacquelain. Bismuth chloride. Potassium sulphate.  
 John. Manganous chloride. Manganous nitrate.  
 Johnson and Crittenden. Ammonium sulphate.  
 Kammer. Antimonic chloride.  
 Karsten. Potassium nitrate. Sodium chloride. Sodium sulphate.  
 Kay. Cadmium iodide.  
 Koene. Ferrous sulphite. Zinc sulphite.  
 Köhler. Mercuric iodide.  
 Kolb. Sodium sulphide.  
 Kopp, H. Antimonous bromide. Antimonous chloride. Calcium chloride. Sodium phosphate.  
 Kopp, M. E. Chronium sulphate.  
 Kraut. Calcium sulphate.  
 Kraut and Precht. See Precht and Kraut.  
 Kraus, E. Barium chloride. Calcium chloride. Sodium chloride. Strontium chloride.  
 Krecke. Manganous chloride.  
 Kretschy. Mercuric chloride.  
 Kühn. Zinc sulphate.  
 Kunheim. Magnesium chloride. Strontium chloride.  
 Labouré. Mercurous iodide.  
 Lang. Cadmium nitrite. Calcium nitrate. Magnesium nitrite. Lead nitrite. Nickelous nitrite. Potassium nitrate. Silver nitrite. Sodium nitrate. Strontium nitrate. Zinc nitrite.  
 Larranaga. Mercurous sulphide.  
 Lassaigue. Chromium sulphide. Manganous iodide.  
 Lefort. Mercurous nitrite.  
 Legrand. Ammonium nitrate.  
 Lensen and Souchay. See Souchay and Lensen.  
 Liebig. Aluminium chloride. Calcium chloride.  
 Loewel. Chromium chloride.  
 Löwig. Cuprous bromide. Ferrous bromide. Lead bromide. Mercuric bromide. Mercurous bromide. Strontium bromide. Zinc bromide.  
 Ludwig. Aluminium phosphate.  
 Lührs. Manganous nitrate.  
 Mac Ivor. Antimonous bromide. Antimonous iodide. Bismuth bromide.  
 Maisch. Ammonium chloride.  
 Mallet. Cuprous chloride.  
 Massignac. Barium chloride.  
 Marchland. Ammonium sulphate.  
 Marx. Bismuth sulphide. Stannous chloride.  
 Maus. Chromium nitrate.  
 Million. Calcium nitrate. Mercuric nitrate.  
 Millon. Calcium sulphate.

- Millot. Ferric phosphate.  
 Mitscherlich. Antimonic sulphide. Arsenious sulphide. Calcium chloride. Calcium sulphate. Ferrous sulphate. Mercuric iodide. Potassium chloride. Potassium nitrate. Potassium sulphate. Sodium bromide. Sodium chloride. Sodium nitrate. Sodium sulphate. Zinc sulphate.  
 Moberg. Chromium chloride.  
 Moissan. Chromium sulphide.  
 Mohr. Mercuric sulphate. Sodium iodide.  
 Muir. Bismuth bromide. Bismuth chloride.  
 Mulder. Barium chloride. Calcium chloride. Magnesium sulphate.  
 Müller. Chromium sulphide.  
 Muspratt. Ammonium sulphite. Barium sulphite. Bismuth sulphite. Calcium sulphite. Chromium sulphite. Cuprous sulphite. Lead sulphite. Magnesium sulphite. Manganous sulphite. Nickelous sulphite. Potassium sulphite. Silver sulphite. Sodium sulphite. Strontium sulphite. Zinc sulphite.  
 Nickels. Bismuth iodide.  
 Odling. Mercurous chloride.  
 Oersted. Aluminium chloride.  
 Oppenheim. Mercuric bromide. Mercuric iodide.  
 Ordway. Aluminium nitrate. Cadmium nitrate. Calcium nitrate. Chromium nitrate. Cupric nitrate. Ferric chloride. Ferric nitrate. Magnesium nitrate. Manganous nitrate. Nickelous nitrate. Strontium nitrate. Zinc nitrate.  
 O'Shea and Carnelley. See Carnelley and O'Shea.  
 Pebal. Ammonium chloride.  
 Peligot. Lead nitrite. Silver nitrite.  
 Penny. Stannous chloride.  
 Percy. Calcium phosphate.  
 Person. Calcium chloride. Potassium nitrate. Sodium nitrate. Sodium phosphate.  
 Personne. Stannic iodide. Stannous iodide.  
 Persoz. Silver nitrate.  
 Petterson. Manganous sulphate. Potassium iodide.  
 Pickering. Ammonium nitrate. Cupric sulphide.  
 Pierre. Arsenious chloride. Nickelous sulphate. Stannic chloride. Zinc nitrate. Zinc sulphate.  
 Plessy. Calcium sulphate.  
 Plisson. Arsenious iodide.  
 Pohl. Silver nitrate.  
 Precht and Kraut. Cadmium sulphate. Ferrous sulphate.  
 Quincke. Potassium nitrate.  
 Rammelsberg. Barium bromide. Barium sulphate. Cadmium sulphite. Calcium sulphite. Cobaltous bromide. Cupric bromide. Ferric sulphide. Magnesium sulphite. Manganous sulphite. Mercurous sulphite. Nickelous bromide. Nickelous phosphate. Nickelous sulphite. Sodium phosphate. Sodium sulphite. Strontium bromide. Zinc sulphite.



- Reichel. Aluminium sulphide. Magnesium sulphide.  
 Reichauer and Vogel, see Vogel and Reichauer.  
 Reynoso. Cobaltic phosphate. Silver phosphate.  
 Riviere. Barium nitrate.  
 Rodwell, F. Lead bromide.  
 Rodwell, G. F. Silver bromide. Silver chloride. Silver iodide.  
 Rodwell and Elder. Mercuric iodide.  
 Rose H. Ammonium sulphate. Antimonous sulphide. Chromium chloride. Cupric chloride. Potassium chloride. Sodium chloride. Sodium phosphate.  
 Roucher. Cupric sulphate.  
 Ruge. Barium nitrate.  
 Saussure. Barium sulphate. Calcium phosphate.  
 Schaffgotsch. Potassium nitrate. Sodium nitrate.  
 Schafrick. Chromium sulphide.  
 Schaurer-Kestner. Ferric nitrate.  
 Schindler. Zinc nitrate.  
 Schlösing. Aluminium nitrate. Manganous nitrate.  
 Schönbein. Ferric nitrate.  
 Schöne. Barium sulphide.  
 Schott. Calcium sulphate.  
 Schröder. Magnesium sulphate.  
 Schultz-Sellack. Antimonous sulphate. Bismuth sulphate. Silver iodide.  
 Schwarzenberg. Silver phosphate.  
 Schweitzer. Ammonium sulphide.  
 Sequin. Mercuric sulphide.  
 Seubert. Ammonium chloride.  
 Sidot. Zinc sulphide.  
 Silbermann and Favre, see Favre and Silbermann.  
 Schneider. Bismuth iodide.  
 Smith. Ferrous iodide.  
 Soubeiran. Cuprous iodide.  
 Souchay and Lensen. Strontium nitrate.  
 Städeler. Mercurous sulphate.  
 Stas. Silver iodide.  
 Stolla. Aluminium sulphate.  
 Storer and Elliot, see Elliot and Storer.  
 Stromeyer. Cadmium chloride. Cadmium iodide. Cadmium sulphate. Cadmium sulphide. Silver phosphate.  
 Strouve. Nickelous phosphate.  
 Serullas. Antimonous bromide. Antimonous iodide. Arsenious bromide. Bismuth bromide. Magnesium bromide.  
 Talbot. Mercuric iodide.  
 Thenard and Gay-Lussac, see Gay-Lussac and Thenard.  
 Thomson. Arsenious iodide. Ferrous iodide.  
 Thorpe. Arsenious chloride. Stannic chloride.  
 Thorpe and Watts. Cobaltous sulphate. Magnesium sulphate. Manganous sulphate. Nickelous sulphate. Zinc sulphate.

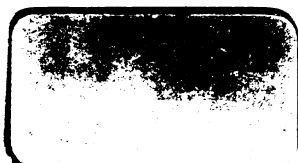
- Todd. Ferrous iodide.  
Traube. Chromium sulphide.  
Trommsdorff. Mercuric phosphate.  
Troost and Deville, see Deville and Troost.  
Van Der Zoon. Zinc sulphate.  
Vanquelin. Sodium sulphite.  
Vanquelin and Foucroy, see Foucroy and Vanquelin.  
Vincent. Arsenious sulphide.  
Vogel. Antimonic sulphide. Cupric chloride. Stannous chloride.  
Vogel and Reischauer. Zinc nitrate.  
Wanklyn and Carius, see Carius and Wanklyn.  
Warrington. Mercuric iodide.  
Weber. Aluminium bromide. Aluminium chloride. Aluminium iodide.  
Wernicke. Silver iodide.  
Werther. Barium iodide.  
Williams and Carnelley, see Carnelley and Williams.  
Wöhler. Aluminium chloride. Chromium bromide. Chromium chloride  
Wöhler and Bauch. Chromium bromide.  
Wright and Menke. Manganous chloride.  
Yvon. Mercurous iodide.

THE END.









Chem 3558.84  
A dictionary of the action of heat  
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